THE INSECTS
OF
AUSTRALIA AND NEW ZEALAND

BY

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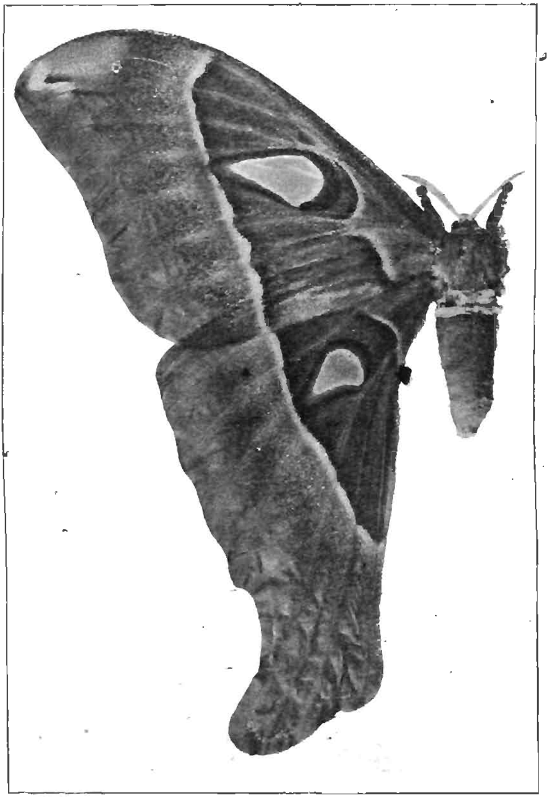

W. C. Davies photo.

Coscinoscera hercules Misk. (Fam. SATURNIIDAE), female.
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OMNIBUS
QUI IN MINIMIS
MIRA NATURAE
PERQUIRUNT

PREFACE

The present volume is intended primarily as a Text-book for use by students of entomology in Australia and New Zealand, secondarily for those who have a general interest in the Insect Life of these countries. Of many good arguments in favour of dealing with the *Insects of Australia and New Zealand in a single volume*, the chief seems to me to be that the New Zealand fauna is in itself so incomplete that a book on it alone would not give the student a fair knowledge of the extent and variety of insect life that exists in most parts of the world. In Australia, on the other hand, all the principal groups are well represented. Thus the New Zealand student can learn from this book, not only the large number of important types of insects missing from his own fauna, but also the relationship that exists between the Australian and New Zealand species of families common to both; while the Australian student will have his interest stimulated in a related fauna of which he knows at present all too little, and at the same time may gather something of the effect of the introduction of a considerable number of Australian insects into New Zealand.

The limits of the work are obviously those of space. It was held to be essential that the student should have as complete a general outline as possible of the Classification and Morphology of Insects, before proceeding to study the more detailed accounts of the separate Orders. The economic aspect of the subject is so vast that it would require a separate volume in which to deal with it; at present, the author has had to be content with indicating the economic significance of each Order in a short section in each corresponding chapter, and mentioning the more important economic insects in the accounts of their special families. The design of each chapter on the Orders of Insects is the same, and consists of sections dealing with Morphology, Life History, Distribution, Fossil History, Economics and Classification, followed by Keys to the Suborders, Superfamilies and Families, with accounts of all the families in each Order. At the beginning of the section on Classification in each chapter, a Scheme of Classification and Census of Species is given, in order to offer to the student a clear representation of the arrangement of Families and Superfamilies within each Order. A selected list of references is given at the end of each chapter, chiefly of works of fairly recent date. A Glossary of biological and entomological terms is added, for the use of the non-biological reader.

It would have been impossible even to have considered undertaking a work covering so large a field, if it had not been for the generous promises of assistance made by numerous friends from the start, promises which were most liberally fulfilled when at last the work came to be undertaken. My thanks are due to my wife for the wash and colour,

work on outlines in pencil drawn by myself for many of the Plates; to Mr. W. C. Davies, Curator of the Cawthron Institute, for the photographs from which the other Plates have been prepared; to Mr. A. Tonnoir, recently Research Student in Diptera, Cawthron Institute, now Assistant Curator, Canterbury Museum, Christchurch, Mr. A. Philpott, Assistant Entomologist, and Mr. E. S. Gourlay, Second Assistant Entomologist, Cawthron Institute, for the drawings from which the text-figures credited to them have been made. I also wish to express my deep indebtedness to Dr. A. Jefferis Turner of Brisbane for the construction of the fine Keys to the Lepidoptera (Heteroneura), for extensive and valuable notes on Australian Lepidoptera incorporated in Chapter xxviii, for much kindly criticism of the same chapter, and for very generous loans of material for study and figuring. To Mr. A. M. Lea, Entomologist of the South Australian Museum, Adelaide, I am equally deeply indebted for a set of valuable notes on Australian Coleoptera incorporated in Chapter xx, including an Australian census for the Order, for much valuable criticism of the same chapter and for the care taken in selecting the material sent on loan for study and figuring by the South Australian Museum, and especially for the loan of the rare Coleopterous Inquilines figured in Plate 16.

My thanks are also due to the following for loans of specimens for study and figuring, and for valuable criticisms of the chapters dealing with the Orders named:—Orthoptera, Dr. A. Eland Shaw, Goodna, Q.; Isoptera, Mr. G. F. Hill, National Museum, Melbourne; Anoplura, Professor L. Harrison, Department of Zoology, University of Sydney; Hemiptera, Mr. F. Muir, H.S.P.A. Experimental Station, Honolulu, T. H., and Mr. J. G. Myers, Biological Laboratory, Wellington (the Key to the Fulgoroidea on page 165 is adapted from one prepared by Mr. Muir); Coleoptera, Mr. H. J. Carter, Wahroonga, N.S.W., Mr. T. Sloane, Moorilla, Young, N.S.W., Dr. E. W. Ferguson, Bureau of Microbiology, Sydney, and Mr. A. E. Brooks, Matamata, New Zealand, (including census of N. Z. Coleoptera); Hymenoptera, Mr. H. Hacker, Queensland Museum, Brisbane, and Mr. A. P. Dodd, Commonwealth Prickly Pear Board, Q.; Diptera, Dr. Ferguson, Mr. Tonnoir, and Mr. G. H. Hardy, Queensland University, Brisbane; Lepidoptera, Dr. G. A. Waterhouse, Killara, N.S.W., Mr. G. Lyell, Gisborne, Vic., and Mr. Philpott; General Morphology, Mr. A. J. Nicholson, Lecturer in Entomology, University of Sydney. Gifts and loans of specimens for study and figuring are also gratefully acknowledged from the Queensland Museum, Brisbane, the Australian Museum, Sydney, the Macleay Museum, University of Sydney, the National Museum, Melbourne, the South Australian Museum, Adelaide, and from Mr. W. W. Froggatt, late Government Entomologist of N.S.W., Mr. W. B. Gurney, Government Entomologist of N.S.W., Mr. L. J. Newman, Government Entomologist of Western Australia, Mr. E. J. Dumigan, Bald Hills, Queensland, Mr. G. Goldfinch, Rose Bay, Sydney, Mr. W. H. Davidson, Mount Tambourine, Q., Mr. W. H. Mathews, Perth, W.A., and Mr. Erasmus Wilson, Melbourne. For valuable criticisms of chapter xxix and help in supplying geological maps and data for same, my thanks are due to Mr. C. Hedley, Scientific Director of the Great Barrier Reef Committee, Professor W. N. Benson, Otago University, Dunedin, and Dr. A. B. Walkom, Linnean Society of N.S.W., Sydney. Nor must I omit to mention my

deep sense of the great value of the geological discoveries made by Professor C. Schuchert and Dr. C. O. Dunbar, of Yale University, New Haven, Conn., in the Lower Permian Insect Beds of Kansas, by Mr. John Mitchell, late Head of the Technical College, Newcastle, N.S.W., in the Upper Permian Insect Beds of Belmont, N.S.W., and Mr. B. Dunstan, Chief Government Geologist of Queensland, in the Upper Triassic Insect Beds of Ipswich, Q. Although this book has not dealt specifically with those finds, the author feels that its plan has been greatly influenced by them and by the unique opportunities of study afforded him by their discoverers.

In compiling Chapter xxx, I have had the assistance of valuable suggestions made by Messrs. A. J. Nicholson, A. Tonnoir, and E. S. Gourlay, to all of whom my thanks are due for their help.

The text-figures are almost all new, though a few have been redrawn from specimens or slides from which figures have already been made for a number of papers published by me in *Proc. Linn. Soc. N.S.W., Trans. Ent. Soc. London, Trans. N.Z. Inst., Journ. Linn. Soc. London, Canad. Entom., N.Z. Journ. Sci. and Technology, Bull. Entom. Research, Mawson Austr. Antarctic Exped. Reports, Trans. Roy. Soc. W. Australia and Trans. Roy. Soc. S. Australia.* Figs. F1, F2, F5, F11, F20 and F21 are taken, with slight alterations, from *The Biology of Dragonflies*, and my thanks are due to the Cambridge University Press for permission to use them. Fig. D1 is used by permission of the Committee on Printing of the Records of the Australasian Antarctic Expedition 1911-14. Fig. ZA10 is taken from a block kindly lent by the Linnean Society of N.S.W. Fig. W5 is from Patton and Cragg's well-known *Text-book of Medical Entomology*. Figs. O1 and O2 are from Professor L. Harrison's papers on *Parasitology*, 1916.

Finally, I desire to express my deep gratitude to the Cawthron Trustees and to Professor T. H. Easterfield, Director of the Cawthron Institute, for the generous manner in which they have extended to me permission and facilities for the writing of this book as part of the official programme of my work during the past three years. Without such permission, and without the full use of the splendid Cawthron Library and the apparatus of the Biological Department, it would have been quite impossible to undertake a work of this magnitude.

R. J. T.

Cawthron Institute,
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CONTENTS

I	CLASSIFICATION AND CENSUS	1
II.	EXTERNAL MORPHOLOGY	9
III.	INTERNAL MORPHOLOGY	30
IV.	LIFE HISTORY	39
V.	THYSANURA	46
VI.	PROTURA	52
VII	COLLEMBOLA	53
VIII	PLECTOPTERA	57
IX.	ODONATA (PARANEUROPTERA)	65
X	ORTHOPTERA	87
XI.	ISOPTERA	100
XII	DERMAPTERA	107
XIII	PERLARIA (PLECOPTERA)	113
XIV	EMBIARIA	120
XV	ZORAPTERA	124
XVI.	COPEOGNATHA (PSOCOPTERA)	126
XVII.	ANOPLURA (INCLUDING MALLOPHAGA)	131
XVIII.	THYSANOPTERA	136
XIX.	HEMIPTERA	140
XX.	COLEOPTERA	176
XXI.	STREPSIPTERA	249
XXII	HYMENOPTERA	252
XXIII	NEUROPTERA	[illegible]
XXIV.	MECOPTERA	326
XXV	DIPTERA	333
XXVI.	SIPHONAPTERA (APHANIPTERA)	[illegible]
XXVII.	TRICHOPTERA	385
XXVIII.	LEPIDOPTERA	396
XXIX.	FOSSIL RECORD AND ORIGIN OF THE AUSTRALIAN AND NEW ZEALAND INSECT FAUNAS	468
XXX.	COLLECTION, PRESERVATION, AND STUDY OF INSECTS	484
APPENDIX I.	GLOSSARY	501
APPENDIX II.	ABBREVIATIONS OF AUTHORS' NAMES	511
INDEX		513

PLATES

ATLAS MOTH—*Coscinoscera hercules* MISK.	1
NEW ZEALAND INSECTS OF VARIOUS ORDERS	2
AUSTRALIAN ODONATA (ZYGOPTERA) .. .	3
AUSTRALIAN ODONATA (ANISOPTERA)	4, 5
AUSTRALIAN ORTHOPTERA, ISOPTERA, AND HEMIPTERA ..	6
ORTHOPTERA AND DERMAPTERA	7
NEW ZEALAND ORTHOPTERA	8
TERMITARIA, OR NESTS OF WHITE ANTS .. .	9
PLECTOPTERA AND PERLARIA	10
AUSTRALIAN INSECTS OF VARIOUS ORDERS	11
HEMIPTERA	12, 13
AUSTRALIAN COCCID GALLS	14
AUSTRALIAN COLEOPTERA	15
AUSTRALIAN INQUILINE COLEOPTERA	16
COLEOPTERA (ADEPHAGA TO STAPHYLINOIDEA)	17
COLEOPTERA (CLAVICORNIA TO LAMELLICORNIA)	18
COLEOPTERA (PHYTOPHAGA AND RHYNCHOPHORA)	19
AUSTRALIAN HYMENOPTERA AND DIPTERA	20
HYMENOPTERA	21
AUSTRALIAN AND NEW ZEALAND NEUROPTERA	22, 24
AUSTRALIAN NEUROPTERA	23
DIPTERA	25
MECOPTERA AND TRICHOPTERA	26
AUSTRALIAN AND NEW ZEALAND LEPIDOPTERA . ..	28
LARGEST AUSTRALIAN SWIFT MOTH—*Leto stacyi* Sc	29
AUSTRALIAN LEPIDOPTERA (HETEROCERA)	27, 30, 32, 35, 36, 37, 39
NEW ZEALAND LEPIDOPTERA	31, 38
PALE SPECIES OF AUSTRALIAN AND NEW ZEALAND LEPIDOPTERA	33
LARGEST AUSTRALIAN HAWK MOTH—*Coequosa triangularis* DON	34
AUSTRALIAN LEPIDOPTERA (RHOPALOCERA) ..	40, 41, 42, 43, 44

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CHAPTER I

CLASSIFICATION AND CENSUS

THE Insects form a Class within the great Phylum Arthropoda, which contains all those Invertebrate Animals having a segmented body provided with paired segmented appendages. The distinctive characters of the Class Insecta are the division of the body into three regions, the *head, thorax* and *abdomen,* of which the head carries the organs of mastication and the principal sense-organs, the thorax the organs of locomotion, viz., three pairs of legs and generally also two pairs of wings, and the abdomen the organs of digestion and reproduction.

The following subdivisions of the Class are here adopted (the names being given in descending order):—Subclass, Order, Superfamily, Family, Subfamily, Tribe, Genus, Species. Keys are given down to families; subfamilies are only mentioned in the case of the larger families, and tribes are not dealt with in this book. In the nomenclature of the different groups, the International Rules for Zoology have been followed as far as possible, though unintentional errors will almost certainly be found to occur. The following points should be especially noted:—

Superfamilies:—The Rules are silent concerning these. They have been primarily adopted in this book in order to simplify the Keys, but in every case they have been carefully thought out so as to offer a grouping of the families in the most natural manner possible. The advantages of a uniform terminology for superfamilies will be obvious to all. The rule laid down and followed in this book is as follows:—To form the superfamily name, select from the families contained in it a type-family, deduct the termination *-idae,* and add the termination *-oidea*. Thus, in the superfamily of Butterflies which includes the Pieridae, Lycaenidae and Nymphalidae (p. 460), the Nymphalidae being selected as type-family, the superfamily name becomes Nymphaloidea. In cases where well-known superfamily names are already in use which do not follow this rule, such names are given as alternatives, and may be used if preferred; thus Coleopterists will probably continue to prefer Heteromera to Tenebrionoidea, Rhynchophora to Curculionoidea etc. (pp. 220, 237).

Families and Subfamilies:—The Rules state that the family name is to be formed by adding *-idae*, and the subfamily name by adding *-inae*, to the *stem* of the type genus. Many family names have been found in which this rule has not been followed, e.g., Cioidae, Lymexylonidae, Myrmeleonidae, Agaonidae, etc. All such have been corrected*, a foot-

*It should be noted that the Rules say nothing about ordinal names, hence the word "Odonata," though wrongly constructed, cannot be altered.

note in each case giving the derivation of the name of the type-genus and its correct stem; the latter is to be found by writing down the *genitive singular* and deducting the terminal inflexion, which is commonly *-ou* or *-os* or *-as* in Greek, *-i*, *-ae*, *-is*, or *-us* in Latin.

A further difficulty arises in the case of the choice of family names where more than one has been in use. The author can find no authority in the Rules for the procedure advocated by some entomologists of deriving the family name in every case from the oldest defined genus within the family. This leads to endless confusion. The rule adopted in this book is to give priority to the first group-name formed from any genus included in the family, provided that such a name was not a vernacular name; i.e., the termination need not necessarily have been *-idae*, or the rank of the group, as at first recognised, that of a family. Thus Mirides Hahn, 1831, a group-name of tribal rank, takes precedence of Capsidae Brullé, 1835, though the latter was of family rank and ended in *-idae*. Had Hahn written "Miriden" (vernacular, in German), the name could not have stood. Obvious exceptions to the rule are such cases as when the name of the type-genus becomes a synonym; in such a case, the family name will change with the generic name, unless another family name has already been given, which must then take precedence.

Genera and Species:—Throughout the book, species are quoted under the Binomial System of Linnaeus, except in a few cases where definite regional subspecies are known to occur, in which case they are given a trinomial name. All specific and subspecific names are followed by an abbreviation of the author's name, the explanation of which will be found in Appendix B. The practice of using specific names by themselves, followed by some entomologists, is quite indefensible; the specific name is simply an adjective in agreement with, or a noun in apposition to, the generic name, and is necessarily attached thereto. The author's name is also a very essential part of the complete name of the species, and should not be omitted.

In the case of genera, the author's name can easily be found from the various well-known Zoological Indices, and has therefore been omitted in this book. Where a species has been commonly known under the wrong genus, or under a subgenus or a synonymic generic name, the author has, for simplicity, placed the rejected name in brackets after the correct generic name. Strictly speaking, this usage is only sanctioned for subgeneric names, and should not be otherwise employed in systematic work.

When a species is placed in a different genus from that under which it was originally described, the Rules require that the author's name should be placed in brackets. These brackets have been omitted in this book owing to the difficulty of checking each individual case; specialists will, of course, be able to supply them for their particular groups.

The Scheme of Classification adopted here is based essentially on the systems of Brauer (1885), Packard (1886) and Handlirsch (1908). A simplification of Handlirsch's very complicated system has been brought about by the retention of the Insecta as a single Class, by the rejection of Superordinal divisions, by the retention of the Cockroaches, Mantids and Phasmatids in the Orthoptera, by the union of the Mallophaga with the Anoplura, and by re-union of the Megaloptera with the Planipennia. The result is that the Class is divided into two Sub-

classes (the larger of which is again divided into two) and twenty-four Orders, which may be defined as follows:—

Class INSECTA.

Subclass APTERYGOTA.

Insects which are entirely wingless, and have never, at any stage of their past history, possessed wings; no marked metamorphosis at any instar (Deriv. *a-* not, and *pterugōtos*, winged).

Order I. THYSANURA (Bristle-tails, Silverfish and allies). Abdomen with ten segments; antennae with many segments; cerci present. (Deriv. *thusanos* fringe, and *oura* tail).

Order II. PROTURA. Abdomen with twelve segments; antennae and cerci absent. (Deriv. *prōtos* first, and *oura* tail).

Order III. COLLEMBOLA. (Spring-tails). Abdomen with six segments, the fourth bearing a ventral springing organ (sometimes vestigial); antennae with only three or four segments; cerci absent. (Deriv. *kolla* glue, and *embolon* a peg or bar, in allusion to the collophore).

Subclass PTERYGOTA.

Insects which either possess wings in their final instar, or, if not, then show by their close relationship to winged forms that they must be descended from such. Metamorphosis more or less marked. (Deriv. *pterugōtos* winged).

Division *ECTOPTERYGOTA* or *HEMIMETABOLA*.

Insects in which the wings develop as external buds or flaps during larval life, and there is no true pupa or resting stage. (Deriv. *ektos* outside, and *pterugōtos* winged; or *hemi-* half, and *metabolē* change).

Order IV. PLECTOPTERA (or EPHEMEROPTERA) (Mayflies). Wings usually reticulate, the hind pair very small or absent; antennae minute; mouth-parts absent. Larva aquatic. Two fully winged instars, viz., subimago with opaque wings, and imago with transparent wings. (Deriv. *plektos* netted or woven, and *pteron* a wing; or *ephēmeros* living but a day, and *pteron*).

Order V. ODONATA (or PARANEUROPTERA). (Dragonflies, damsel-flies). Body elongate; wings reticulate, equal or subequal, with nodus and pterostigma; antennae minute; mouth-parts strongly mandibulate. Larva aquatic. (Deriv. *odous*, gen. *odontos* a tooth; or *para* alongside of, and Neuroptera).

Order VI. ORTHOPTERA (Cockroaches, Mantids, Phasmids, Locusts, Grasshoppers and Crickets). Wings reticulate, unequal, the forewing more or less thickened to form a tegmen covering the hind, which has a longitudinally folded anal fan; mouth-parts mandibulate. Larva terrestrial. (Deriv. *orthos* straight, and *pteron* a wing).

Order VII. ISOPTERA (White Ants or Termites). Wings subequal, cast off soon after metamorphosis; hindwing without a folded anal area, except in *Mastotermes;* mouth-parts mandibulate. Social insects, living in nests, with queen, king, workers and soldiers. (Deriv. *isos* equal, and *pteron* a wing).

Order VIII. DERMAPTERA (Earwigs). Wings very unequal; forewing a small tegminous flap, beneath which the large membranous hindwing folds up in a complicated manner; mouth-parts mandibulate. Larva terrestrial. Deriv. *derma* skin, and *pteron* a wing).

Order IX. PERLARIA (or PLECOPTERA) (Stoneflies). Wings open or reticulate, unequal, the forewing forming a covering for the hind, but seldom much thickened; hindwing with an anal fan, sometimes not very large; mouth-parts mandibulate; antennae long; cerci present, long or short. Larva aquatic. (Deriv. Perlaria from *Perla*, principal genus; or *plekein* to fold, and *pteron* a wing).

Order X. EMBIARIA (Web-spinners). Wings of male equal, narrow, wide apart, the venation slight, partially or almost wholly replaced by pigment-bands; female wingless; mouth-parts mandibulate; fore legs with an enlarged spinning-gland; cerci 2- or rarely 1-segmented. Larva terrestrial, living in webs. (Deriv. from *Embia,* principal genus).

Order XI. ZORAPTERA. Social insects with winged and wingless adult forms; in the former, wings unequal, narrow at base, hindwing shorter and narrower than fore, venation very simple; mouth-parts mandibulate; tarsi with two segments; cerci present, unsegmented; winged forms with compound eyes and ocelli, wingless forms blind. (Deriv. from *zōros* pure, and *apteros* wing-

less, in allusion to the wingless adults, which were discovered first).

Order XII. COPEOGNATHA (or PSOCOPTERA). (Psocids, Book-lice). Wings unequal, the hind shorter and narrower than the fore; venation highly specialized, with few or no cross-veins; mouth-parts mandibulate, with a pair of long, slender gouging organs or chisels; cerci small, unsegmented. Larva terrestrial. (Deriv. *kopeus* a chisel, and *gnathos* a jaw; Psocoptera from *Psocus*, principal genus).

Order XIII. ANOPLURA (including MALLOPHAGA) (Biting and Sucking Lice). Very small, dorsoventrally flattened, wingless parasites on warm-blooded Vertebrates; mouth-parts either mandibulate or vestigial (in which case the hypopharynx is developed for suction). Metamorphosis very slight. (Deriv. *anoplos* unarmed, and *oura* a tail; *mallos* hair, and *phagein* to eat).

Order XIV. THYSANOPTERA (Thrips). Body narrow; wings small, slender, equal, with a wide fringe of hairs, and little or no venation; mouth-parts asymmetrically developed for rasping, lacerating or piercing plant tissues. Larva terrestrial, living on plants, either freely or in galls. (Deriv. *thusanos* a fringe, and *pteron* a wing).

Order XV. HEMIPTERA (or RHYNCHOTA) (Bugs, Cicadas, Plant and Leaf-hoppers, Plant-lice, Scale Insects). Wings unequal, the fore longer and narrower than the hind and forming a covering for it, usually more or less tegminized; mouth-parts forming a sucking beak. Larva terrestrial or aquatic; metamorphosis slight to considerable (closely approximating to the Holometabolous condition in Aleurodidae and male Coccidae). (Deriv. *hemi-* half, and *pteron* a wing; or *runchōtos* having a snout).

Division *ENDOPTERYGOTA* or *HOLOMETABOLA*. Insects in which the wings develop internally during larval life, and there is a true pupa or resting stage. (Deriv. *endon* inside, and *pterugōtos* winged; or *holos* whole, and *metabolē* change).

Order XVI. COLEOPTERA (Beetles, Weevils). Forewing a tough elytron or wing-cover, without any venation; hindwing membranous, usually with an expanded anal area and distinct venation, and almost always infolded at the

apex; mouth-parts mandibulate. Larva variable in form, pupa nearly always a *pupa libera*, not enclosed in a cocoon. (Deriv. *koleōs* a sheath, and *pteron* a wing).

Order XVII. STREPSIPTERA. Very small insects parasitic on Hymenoptera and Hemiptera. Males winged, the forewing a minute scale, the hind broad and membranous. Females larviform, remaining partially buried in the host. The males have a pupal stage and marked metamorphosis. (Deriv. *strepsis* a twisting, and *pteron* a wing).

Order XVIII. HYMENOPTERA (Saw-flies, Ichneumon-flies, Wasps, Ants, Bees.) Wings formed of a tough, transparent membrane, the forewing longer than the hind, and connected with it in flight by a series of minute hooklets; venation usually strong, divided by cross-veins into a moderate number of irregular cells; mouth-parts always mandibulate, but sometimes also developed for feeding on nectar. Larvae cruciform or vermiform, phytophagous or parasitic; pupa a *pupa libera*, often in a cocoon. (Deriv. *humēn* a membrane, and *pteron* a wing).

Order XIX. NEUROPTERA (including MEGALOPTERA and PLANIPENNIA). (Alder-flies, Lacewings and allies). Wings equal or subequal, membranous, usually with more or less complex venation, and held roof-wise over the back when at rest; mouth-parts mandibulate; head not produced into a rostrum (except in Nemopteridae). Larva predaceous, aquatic or terrestrial; pupa a *pupa libera*, often in a cocoon spun from the anus. (Deriv. *neuron* a sinew, and *pteron* a wing).

Order XX. MECOPTERA (Scorpion-flies). Wings long, narrow, equal, held roof-wise when at rest; venation with a system of cross-veins at fairly wide intervals; head more or less prolonged into a rostrum, with mouth-parts complete or nearly so, but the mandibles elongated and spear-like. Larva cruciform; pupa a *pupa libera*, not in a cocoon. (Deriv. *mēkos* length, and *pteron* a wing).

Order XXI. DIPTERA (Two-winged flies). Forewings membranous with rather narrow bases; venation open with few or no cross-veins; hind-wings absent, replaced by a pair of small

balancers or *halteres*; mouth-parts specialized for piercing or sucking. Larva variable in form, terrestrial or parasitic, never with thoracic legs; pupa a *pupa libera* or *pupa incompleta*, in the higher groups developed inside the hardened larval skin or *puparium*. (Deriv. *di-* twice or double, and *pteron* a wing).

Order XXII. SIPHONAPTERA (or APHANIPTERA) (Fleas). Small, laterally flattened parasites on warm-blooded vertebrates. Wings absent; mouth-parts specialized for piercing and sucking, with spear-like mandibles; hind legs developed for jumping. Larva an elongated, legless grub; pupa in a cocoon. (Deriv. *siphōn* a tube, and *pteron* a wing, or *aphanēs* not apparent, and *pteron* a wing).

Order XXIII. TRICHOPTERA (Caddis-flies). Wings membranous, sub-equal or unequal, covered with dense hairs (rarely with scales); mouth-parts reduced, the mandibles absent or vestigial, only the palps well developed. Larva aquatic, generally in a movable case or fixed house; pupa a *pupa libera*, sometimes in a cocoon. (Deriv. *thrix*, gen. *trichos* a hair, and *pteron* a wing).

Order XXIV. LEPIDOPTERA (Moths, Butterflies). Wings membranous, sub-equal or equal, covered all over with scales; mouth-parts (except in Micropterygidae) developed for sucking nectar, the mandibles absent, the galeae elongated to form a sucking tube or haustellum. Larva a caterpillar; pupa nearly always a *pupa incompleta* or *pupa obtecta*, often in a cocoon. (Deriv. *lepis* a scale, and *pteron* a wing).

CENSUS OF THE INSECTA.

he following Table gives the latest estimates of the number of species : the various Orders for (a) the World, (b) Australia, (c) New ealand. Introduced species are not counted in lists (b) and (c), but certain cases a number of undescribed species known to exist in llections are included; this applies chiefly to the smaller Orders and e Diptera, the total for the latter including all the species of Nematocera recently collected in New Zealand and Tasmania by M. Tonnoir, hich will shortly be described by him, as well as the estimated total New Zealand Tipulidae (500) given by Dr. Alexander, only about a lf of which have so far been described. The World totals are taken om a recent estimate given in the *Entomological News*, 1923, xxxiv, 122.

Order, etc.	(a) World	(b) Australia	(c) New Zealand
Apterygota:—	**1,410**	**62**	**20**
Thysanura	360	20	5
Protura	15	0	0
Collembola	1,030	42	15
Ectopterygota:—	**58,770**	**3,680**	**510**
Plectoptera	450	20	20
Odonata	2,600	200	13
Orthoptera	14,400	1,110	80
Isoptera	500	120	3
Dermaptera	740	40	3
Perlaria	480	25	22
Embiaria	60	6	0
Zoraptera	6	0	0
Copeognatha	600	30	18
Anoplura	1,430	90	50
Thysanoptera	500	70	0
Hemiptera	37,000	1,970	300
Endopterygota:—	**409,910**	**33,340**	**7,620**
Coleoptera	195,000	16,660	4,430
Strepsiptera	150	7	0
Hymenoptera	67,500	6,250	310
Neuroptera	2,140	250	13
Mecoptera	170	12	1
Diptera	51,000	2,120	1,620
Siphonaptera	350	30	2
Trichoptera	1,600	60	50
Lepidoptera	92,000	7,940	1,190
Total INSECTA:—	470,090	37,080	8,150

Note:—Except for small totals of 25 and under, the figures are given in round numbers to the nearest ten.

In the Chapters on the separate Orders a Scheme of Classification and Census for Australia and New Zealand is given for each Order. The numbers for Australia are quoted first, followed by those for New Zealand in brackets. In each Order, the most archaic groups are placed first, the most highly specialized last.

For References, see end of Chap. IV.

CHAPTER II

EXTERNAL MORPHOLOGY

The body of an Insect consists of a number of complete rings or segments, usually nineteen in number, though not all of these can be clearly made out, except in the embryo. There are three very distinct regions of the body, as follows:—

1. *The Head*:—This is a fused mass formed of six embryonic segments whose boundaries are no longer visible. It carries the principal organs of sense and all the organs of feeding.
2. *The Thorax*:—This is usually the most strongly built region of the body. It consists of three distinct segments, and carries the organs of locomotion, namely, three pairs of legs and two pairs of wings.
3. *The Abdomen*:—This is a more or less elongated region placed behind the thorax, and composed normally of ten complete segments (see p. 28 note). It carries the internal organs of digestion and circulation, the internal and external organs of reproduction and frequently also a pair of terminal appendages called cerci.

THE SKELETON AND SEGMENTATION

The skeleton of an insect is the hard part which resists decay after death; that is to say, the dried specimens which are kept in our collections and studied systematically are really little more than the skeletons of the original insects, though shrivelled remains of some of the internal organs may still be present.

The skeleton is chiefly external, forming an almost completely hard covering to the internal organs. It is composed of *chitin*, a substance resembling horn, and remarkable in being resistant to both acids and alkalies, though it is slowly decomposed by water. The layers of chitin which form the outer skeleton are called the *cuticle*; they are secreted by a single layer of living cells known as the *hypodermis*, which underlies them everywhere in the living insect.

Owing to its lack of elasticity, the outer skeleton of an insect, like that of other Arthropods, is unable to grow as the animal grows. Hence, at certain times in the insect's life, the whole of the cuticle with all its internal extensions is cast off, and the hypoderm cells form beneath it a fresh cuticle of large size, capable of lasting for a further period of growth. The act of casting the cuticle is called an *ecdysis*; the stage of growth between two successive ecdyses is known as an *instar*. The

cast cuticle is called the *exuviae*, and is often of considerable value for study.

The segmented condition of an insect's body is very clearly marked in the skeleton of the thorax and abdomen, but is more or less hidden by fusion of the parts in the head region. The head is therefore usually considered as a single unit, the *head-capsule*. In the case of the thorax and abdomen, the segments are more or less divided from one another by narrow rings of very soft connecting membrane or *conjunctiva*, which is frequently infolded so as to produce a *suture*; these are more marked in the abdomen than in the thorax, and give to the former greater mobility.

A typical *segment* of the skeleton consists of four distinct regions:—a dorsal region or *tergum*, right and left lateral regions or *pleura*, and

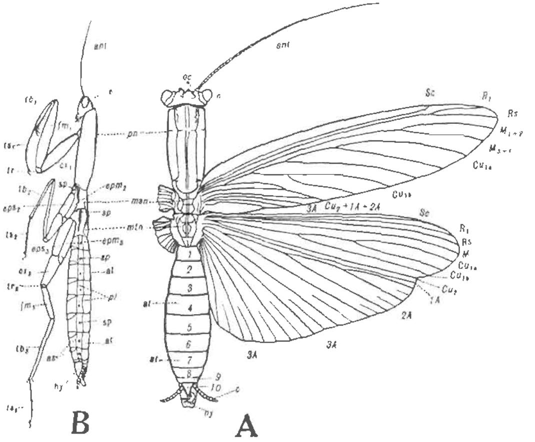


FIG. A1. Green Mantis, *Orthodera ministralis*, Fabr., Australia and New Zealand (Order Orthoptera, fam. Mantidae), to illustrate the general structure of an insect. A, dorsal view; B, lateral view; 1, 2, 3, ... 10, the ten abdominal segments; *ant*, antenna; *as*, abdominal sternite; *at*, abdominal tergite; *c*, cercus; *cx*, coxa; *e*, compound eye; *epm*, epimeron; *eps*, episternum; *fm*, femur; *hy*, hypandrium (= ninth sternite, in male only); *oc*, ocellus; *pl*, abdominal pleurite; *sp*, spiracle; *st*, sternum; *tb*, tibia; *tr*, trochanter; *ts*, tarsus. Suffixes 1, 2, 3 indicate parts of pro-, meso- and meta-thorax respectively, or of fore, middle and hind legs respectively. Lettering of venation as in fig. A8, p. 22 [R. J. T. del.

a ventral region or *sternum*. In the thorax, all these regions are strongly chitinized; in the abdomen, only the terga and sterna are thus hardened, the pleura being formed of soft, membranous chitin.

The separate hard pieces of chitin of which a segment is composed are termed *sclerites*. The sclerites of a tergum are called *tergites*; those of a pleuron, *pleurites*; those of a sternum, *sternites*. A tergum, pleuron or sternum may be composed of a single sclerite, or it may be divided into two or more sclerites distinctly separated by grooves formed

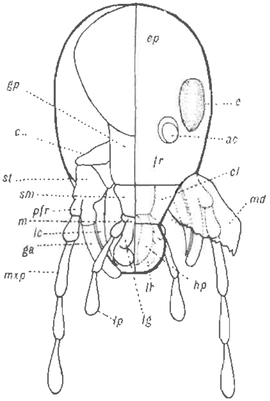
by ingrowth of the cuticle. These ingrowths are known as *apodemes*. Their function is to provide strong supports for the attachment of muscles. The complete system of apodemes is called the *endoskeleton*.

The complex endoskeleton of the head is called the *tentorium* (see p. 12). In the thorax, an apodeme developed from a tergite is called a *phragma*, from a pleurite, a *lateral apodeme*, and from a sternite, a *furca*.

THE APPENDAGES

A primitive Arthropod is formed of a number of closely similar *segments*, each of which carries a pair of movable *appendages*. These appendages are themselves segmented, the segments being movable on one another. The term *segment* is correctly used either for a separate ring of the body or for a separate ring of an appendage. A *joint* is the articulated area between two segments, e.g., the knee-joint between femur and tibia. To speak of the separate pieces or rings of an antenna or a palp as "joints" is incorrect; the term *segment* will be used throughout this book.

In the Insecta, which are the most highly specialized of all Arthropods, the segmental appendages have become highly modified to perform different functions; those of the head as sense organs (antennae) or as mouth-parts (mandibles, maxillae, labium); those of the thorax



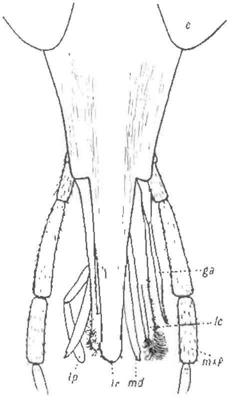


FIG. A2 (left). Head of Common Tree Weta, *Hemideina megacephala* Buller, New Zealand, Order Orthoptera, fam. Tettigoniidae. Right half, dorsal view; left half, ventral view; *ac*, antennal cavity or torulus; *c*, cardo; *cl*, clypeus; *e*, compound eye; *ep*, epicranium; *fr*, frons; *ga*, galea; *gp*, gular plate; *hp*, hypopharynx; *lc*, lacinia; *lg*, ligula; *lp*, labial palp; *lr*, labrum; *m*, mentum; *md*, mandible; *mxp*, maxillary palp; *sm*, submentum; *st*, stipes. [*A. Tonnoir del.*

FIG. A3 (right). Rostrum and mouth-parts of Scorpion-fly, *Harpobittacus tillyardi* E.P., Australia (Order Mecoptera, fam. Bittacidae), to show elongate piercing type. Lettering as in Fig. A2. Right mandible, and galea and lacinia of left maxilla, somewhat displaced, left labial palp omitted. [*A. Tonnoir del.*

PLATE 2

NEW ZEALAND INSECTS OF VARIOUS ORDERS

All figures natural size, except figs. 6 and 7.

Order PLECTOPTERA

1. *Ameletus perscitus* Eat. (Fam. SIPHLONURIDAE), female subimago.
2. *Atalophlebia dentata* Eat. (Fam. LEPTOPHLEBIIDAE), male imago.

Order ODONATA

3. *Xanthocnemis zelandica* Sel. (Fam. AGRIIDAE), male.
4. *Procordulia grayi* Sel. (Fam. CORDULIIDAE), male.

Order PERLARIA

5. *Stenoperla prasina* Newm. (Fam. EUSTHENIIDAE).

Order COPEOGNATHA

6. *Myopsocus novae-zelandiae* Kolbe (Fam. MYOPSOCIDAE) (x 1.3).
7. *Zelandopsocus formosellus* Till. (Fam. MESOPSOCIDAE) (x 3).

Order HEMIPTERA

8. *Arocatus ruficollis* Walk. (Fam. LYGAEIDAE).
9. *Melampsalta cingulata* Fabr. (Fam. CICADIDAE), male.
10. *Philaenus trimaculatus* F.B.W. (Fam. CERCOPIDAE).
11. *Thanatodictya tillyardi* Myers (Fam. DICTYOPHORIDAE).

Order COLEOPTERA

12. *Chlorochiton suturalis* Fabr. (Fam. SCARABAEIDAE).
13. *Pyronota festiva* Fabr. (Fam. SCARABAEIDAE).
14. *Calliprason sinclairi* Wh. (Fam. CERAMBYCIDAE).
15. *Navomorpha lineata* Fabr. (Fam. CERAMBYCIDAE).
16. *Zorion minutum* Fabr. (Fam. CERAMBYCIDAE).
17. *Phacodrophilus o'connori* Broun (Fam. CURCULIONIDAE)
18. *Lyperobius hudsoni* Broun (Fam. CURCULIONIDAE).

Order HYMENOPTERA

19. *Megarhyssus fractinervis* Voll. (Fam. ICHNEUMONIDAE)
20. *Salius wakefieldi* Kby. (Fam. PSAMMOCHARIDAE).

Order NEUROPTERA

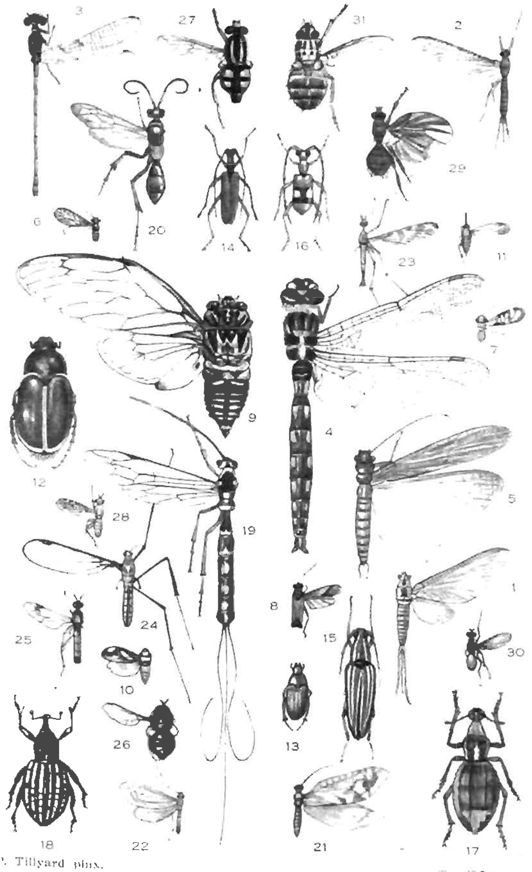
21. *Euosmylus stellae* McL. (Fam. OSMYLIDAE).

Order TRICHOPTERA

22. *Olinga feredayi* McL. (Fam. SERICOSTOMATIDAE).

Order DIPTERA

23. *Tanyderus forcipatus* O.S. (Fam. TANYDERIDAE).
24. *Macromastix ferruginea* Edw. (Fam. TIPULIDAE).
25. *Neoexaireta apicalis* Hutt. (Fam. STRATIOMYIIDAE).
26. *Apsona muscaria* Wwd. (Fam. CYRTIDAE).
27. *Helophilus antipodum* Sch. (Fam. SYRPHIDAE).
28. *Limnia obscura* Hutt. (Fam SCIOMYZIDAE).
29. *Exul singularis* Hutt. (Fam. ANTHOMYIIDAE).
30. *Phania verecunda* Hutt. (Fam. TACHINIDAE).
31. *Hystricia pachyprocta* Now. (Fam. TACHINIDAE).



R. Tillyard pinx.

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NEW ZEALAND INSECTS OF VARIOUS ORDERS

for progression (legs); those of the abdomen, where still retained, as aids in reproduction (gonapophyses) or terminal sense organs (cerci).

It should be noted that certain prominent external organs are not true segmental appendages, viz., the compound eyes, the ocelli, the labrum, the wings, two out of the three pairs of gonapophyses and the appendix dorsalis. With the single exception of the last-named, none of these are ever segmented.

THE HEAD

The skeleton of the head forms a hardened capsule, usually more or less globular or oval in form, and attached to the thorax by a more or less constricted *neck*; the region of attachment is perforated by a more or less circular opening called the *posterior foramen*, easily seen by detaching the head from the thorax. Through this foramen pass the dorsal aorta, the oesophagus, the central nervous system, and a pair of large tracheae. Below it the capsule is closed by a median plate, called the *gular plate*, generally considered to be the sternite of the sixth or last head-segment; this plate carries the *labium* or lower lip, which borders the mouth from below. Dorsally, from the foramen to the mouth, the capsule is very hard and usually very convex; in most insects two small sclerites only are to be seen in the anterior portion of this region, while all the upper and posterior part forms a fused whole. Of the two small anterior sclerites, one is a movable flap, the *labrum* or upper lip, bordering the mouth from above; the other, situated directly above the labrum, is a fixed sclerite called the *clypeus*. The rest of the dorsal part of the head is called the *epicranium*; as its limits are so extensive, the posterior portion is distinguished as the *occiput*, the upper portion as the *vertex*, and the anterior portion, situated above the clypeus, as the *frons*. In a few archaic insects (e.g., Copeognatha, fig. N1, B), the epicranium is divided longitudinally by a median suture, the *epicranial suture*. Anteriorly this suture has two arms running out towards the right and left eye respectively. The part enclosed between the arms and the clypeus is the true *frons*, which is thus seen to have been originally a separate sclerite. The frons originally carried the antennae and median ocellus, while the compound eyes and lateral ocelli were situated on the right and left halves of the epicranium proper. When, as in most insects, the epicranium and frons form an undivided whole, the ocelli are grouped in a small triangle between or behind the compound eyes, on that part of the epicranium called the vertex. In some insects the clypeus is not distinct from the frons; in others the clypeus may be divided into two parts, an *anteclypeus* and a *postclypeus*. The lateral portions of the epicranium below the compound eyes are termed the *genae* or cheeks.

The internal skeleton of the head is called the *tentorium*. It is formed by three (sometimes only two) pairs of apodemes which fuse within the head, forming a kind of platform on which the brain rests. A fairly large opening in this plate separates off the *frontal plate* from the *body of the tentorium*. The frontal plate is formed by the fusion of a pair of anterior or fronto-clypeal apodemes; the body of the tentorium by fusion of a pair of dorsal apodemes and a pair of posterior apodemes. The oesophagus and connectives of the brain pass through the opening in the tentorium. The frontal plate separates the opening of the oesophagus (above) from the salivary ducts (below).

In the head of the embryonic insect, the mouth is formed between

the third and fourth segments. The nerve ganglia of the first three or preoral segments fuse together to form the *brain* or *supra-oesophageal ganglion*, while those of the last three or postoral segments also fuse together, forming a separate mass, the *suboesophageal ganglion*. These two large ganglia are separated by the tentorium, but are united by short *connectives* between which the oesophagus passes. The following Table shows the segments of the head, their ganglia, and the segmental appendages and other organs belonging to them:—

TABLE OF THE HEAD SEGMENTS.

Segment.	Ganglia.		Segmental Appendages.	Other Organs.
1. Ocular.	Protocerebrum	=Brain	None.	Compound eyes. Lateral ocelli.
2. Antennary.	Deutocerebrum		Antennae.	Median ocellus.
3. Intercalary.	Tritocerebrum		None.	(gives off sympathetic nervous system.)
4. Mandibular.	Suboesophageal Ganglion.		Mandibles.	
5. Maxillary.			First Maxillae.	
6. Labial.			Fused Second Maxillae (=Labium).	

Note.—The compound eyes are not usually considered to be true segmental appendages, but it should be recalled that in Crustacea they are frequently carried on movable stalks, and, when cut off, may be regenerated as a pair of antenna-like organs.

On the question of the supposed extra or maxillulary segments in Insects, see below, p. 17, under "Hypopharynx."

The *Compound Eyes* (fig. A2, *c*). These are present in the great majority of insects, and are usually placed on both sides of the epicranium. In some species they are frequently so large as to meet one another in the middle line for a greater or less distance; such species are said to be *holoptic*, as contrasted with those having separated eyes, which are said to be *dichoptic*. Externally, each compound eye consists of a large number of hexagonal *corneal lenses* formed of transparent chitin; each corneal lens is the outer covering of a single eye element, or *ommatidium*, of complex formation, and connected at its inner end with a nerve from the optic ganglion (part of the protocerebrum). In primitive forms, the compound eyes are usually present at the birth of the larva; but in the Holometabola this is only true of the Mecoptera, one or two Diptera, and the Lepidopterous family Micropterygidae. Degraded compound eyes in which the few remaining ommatidia have their lenses quite separate, and consequently rounded instead of hexagonal, occur in Collembola, in many parasitic insects, and in specialized larvae. The error of calling such organs *ocelli* is common amongst systematists, but should be avoided; the terms *ommatidia*, *ommata* or *separate eye-elements* may be used for them.

The *Ocelli* (fig. A1, *oc*). In most insects three ocelli or simple eyes are present, situated in a small triangle on the vertex. Each ocellus has a single lens, but differs from an ommatidium of a compound eye in that this lens covers a large number of internal eye-elements. The most anterior ocellus is situated in the middle line, and is called the *median ocellus*: its structure shows that it was originally two separate ocelli which became fused together; and, indeed, it still receives two distinct nerve supplies from right and left lobes of the deutocerebrum. The other two ocelli are called the *lateral ocelli*; each receives only a single nerve supply, namely, from the right or left side

of the protocerebrum. Unlike the compound eyes, the ocelli are not present in the young larvae, but only develop very late in larval life, or at metamorphosis.

The *Antennae* (fig. A1, *ant*). These are segmented, movable appendages situated in sockets (*toruli*) placed more or less between or in front of the compound eyes. A typical antenna consists of a basal segment or *scape*, a second segment or *pedicel*, both more or less specialized, followed by a variable number of closely similar, smaller segments which together form a whip-like portion or *flagellum*. The scape carries internally the insertions of the muscles which move the organ as a whole. The pedicel is almost entirely filled with a mass of nerve cells called a Johnston's organ (p. 36). Minute organs of smell and hearing may also be present on some or all of the segments. The antenna as a whole is often used also as a feeler or organ of touch, especially in those forms in which the flagellum is greatly elongated.

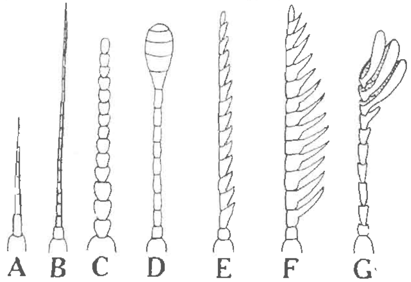


FIG. A4. Types of Insect Antennae: A, subulicorn; B, filiform; C, moniliform; D, clavate; E, serrate; F, pectinate; G, lamellate. [R. J. T. del.

Antennae are of many diverse forms, of which the following are the most important (see fig. A4):—

1. *Subulicorn*, or awl-like (fig. A4, A). Exceedingly short, straight and pointed, the flagellum with few segments, often indistinctly separated (Plectoptera, Odonata). Such antennae cannot be used as feelers, and are only suited to entirely aërial insects.
2. *Filiform*, or thread-like (fig. A4, B). Each segment of the flagellum is elongate, slender, cylindrical, and their number is large, so that the flagellum resembles a long thread or lash.
3. *Moniliform*, or like a string of beads (fig. A4, C). Each segment of the flagellum is more or less swollen, globular or flask-shaped.
4. *Clavate*, or clubbed (fig. A4, D). The terminal segments of the flagellum are swollen into a distinct club. If the club is very large, the antenna is said to be *capitate*.
5. *Ciliate* or fringed. Each segment is furnished with soft, delicate hairs, often arranged in whorls.
6. *Serrate* or saw-like (fig. A4, E). Each of the segments of the flagellum projects inwards with a sharp angle, like the teeth of a saw.

7. *Pectinate* or comb-like (fig. A4, F). Similar to (5), but the projections are longer, like the teeth of a comb; if there are two rows of such projections, the antennae are *bipectinate*.
8. *Flabellate*. Similar to (6), but the projections still longer and not so rigid.
9. *Lamellate* (fig. A4, G). The terminal segments of the flagellum are expanded on one side only into broad flat plates.
10. *Elbowed or geniculate*. The scape is more or less elongated, and the rest of the antennae is set at an angle to it.

Other still more highly specialized forms occur; see Curculionoidea, (fig. R69), Chalcidoidea (fig. T22), and Cyclorrhapha (p. 365).

The Mouth-parts

The mouth of an insect is closed above by the upper lip or *labrum*, below by the lower lip or *labium*, and carries at the sides two pairs of movable jaws, the *mandibles* and *maxillae*. If the mouth and its appendages are situated in front of the head, the insect is said to be *prognathous*; if below the head, *hypognathous*.

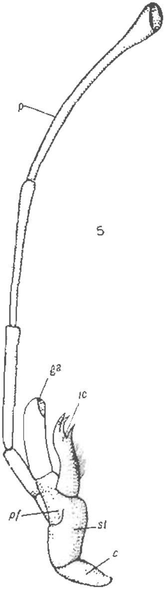
The *Labrum* (fig. A2, *lr*), or upper lip, is normally a broad, movable flap attached to the lower margin of the clypeus; its outer margin is usually entire, seldom emarginate or medially incised. On the inner side it is soft and membranous, and more or less abundantly furnished with small tactile hairs and minute organs of taste; this portion is called the *epipharynx*. In some insects having piercing mouth-parts, the labrum and epipharynx may be greatly elongated and sharply pointed. The complete organ is often called the *labrum-epipharynx*.

The *Mandibles* (fig. A2, *md*) are a pair of strongly chitinized, toothed jaws situated on either side of the mouth just below the labrum. They are worked by the most powerful muscles of the head, and are articulated with the head-capsule by a true ginglymus joint. In the normal (primitive) biting types of insect these jaws are the principal agents in feeding, being used to bite off and chew up the food. In the more specialized piercing and sucking types, they become transformed into spear-like organs (fig. A3, *md*), or they may degrade to functionless vestiges, or even entirely disappear. They never carry a palp.

The *Maxillae* (fig. A2), or First Maxillae, are a second pair of jaws situated on either side of the mouth below the mandibles and a little above the labium. Their chief function is to select the food by taste and touch; only seldom do they carry strong teeth for biting or chewing, as in Odonata. A complete maxilla consists of a basal piece or *cardo* (*c*), followed by a longer distal segment or *stipes* (*st*), from which there project two inner and usually unsegmented lobes or processes (gnathobases) and an outer segmented appendage or palp. The innermost process is called the *lacinia* (*lc*); it is usually weakly chitinized and carries hairs and taste-buds. Next to the lacinia comes the outer process or *galea*, (*ga*), also usually weakly chitinized and carrying hairs and taste-buds, but generally broader than the lacinia. In some forms, only a single process is found, spoken of as the *inner lobe* of the maxilla. The *palp* arises from the outer distal portion of the stipes, which is often constricted off from the rest as a separate piece called the *palpifer* (*pfr*). The usual number of segments in the maxilliary palp is five, but Machilidae have seven, and most Hymenoptera six, while reductions in the number are quite common. The palp has been shown to be the homologue of the endopodite of the Crustacean appendage, in

spite of its outer position in the Insects; the true exopodite of the Crustacea is not represented in the Insecta.

The maxillae undergo some remarkable specializations in certain insects. In Beetles (fig. R2), the galea is often two-segmented, and even the lacinia may carry a terminal movable hook; both processes may be very hard and strongly chitinized. In Odonata (fig. F2, B) the inner lobe is hard and carries strong teeth; it assists the mandible to bite and chew the food. In Thysanoptera (fig. P1) the two maxillae are developed asymmetrically (p. 137). In piercing or sucking types, the inner lobe, the lacinia or the galea may develop into a long slender spear, and the palp may become greatly reduced or entirely disappear; in Lepidoptera (fig. Z2), the lacinia disappears and the two galeae together form the haustellum or coiled sucking tube (p. 397).



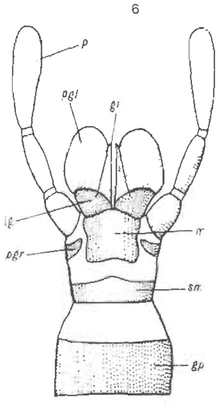


FIG. A5. First maxilla of the Cave Weta, *Pachyrhamma fascifer* Walk., New Zealand (Order Orthoptera, fam. Tettigoniidae); c, cardo; *ga*, galea; *lc*, lacinia; *p*, palp; *pf*, palpifer; *st*, stipes. [*A. Tonnoir del.*

FIG. A6. Gular plate and Labium (Second Maxillae) of the Cave Weta, *Pachyrhamma fascifer* Walk.; *gl*, glossa; *gp*, gular plate; *lg*, ligula; *m*, mentum; *p*, palp; *pgl*, paraglossa; *pgr*, palpiger; *sm*, submentum. [*A. Tonnoir del.*

The *Labium* (fig. A6), lower lip, or fused Second Maxillae, is a complex organ formed by the fusion of two separate maxillae having all their parts homologous with those of the first maxillae already de-

two fused cardines of the maxillae; next to this is a distal piece, the *mentum*, (*m*), corresponding with the two fused stipites of the maxillae. From the sides or anterior angles of the mentum, or sometimes from a separate piece called the *palpiger*, (*pgr*), project the two *palpi*, usually three-segmented (in most Hymenoptera they have four segments, while reductions in the number are quite common). The anterior border of the mentum carries normally two pairs of processes, an inner pair called the *glossae* (*gl*), corresponding with the laciniae of the first maxilla, and an outer pair called the *paraglossae*, (*pgl*), corresponding with the galeae of the same. Sometimes these processes are carried on a separate piece marked off from the rest of the mentum; the term *ligula* (*lg*) may be applied to this piece; when the processes are fused together, the term *internal lobe* is used for the whole piece.

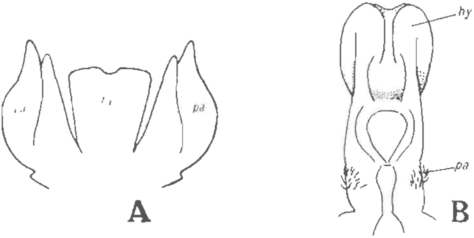


FIG. A7. Hypopharynx and side-lobes or paragnaths A. of *Nesomachilis maoricus* Till., New Zealand (Order Thysanura, fam. Machilidae), and B. of *Pachyrhamma fascifer* Walk., New Zealand (Order Orthoptera, fam. Tettigoniidae); *hy*, hypopharynx; *pa*, paragnath. [*A. Tonnoir del.*

The *Hypopharynx* (fig. A7, *hy*). Within the cavity of the mouth, in most insects, there is to be seen an unpaired, tongue-like organ, called the *hypopharynx*. This organ forms the lower border of the pharynx proper, and extends back as far as the opening of the oesophagus. In the fold between it and the labium the salivary ducts open. The hypopharynx arises actually between mandibles and maxillae, and in some archaic insects it carries a pair of side-lobes (fig. A7, *pa*), which may be finely toothed or furnished with delicate hairs and taste-buds; in some cases, these lobes are membranous like the rest of the hypopharynx, which then appears as a trifid tongue. These lobes have been called *maxillulae* by Hansen (1893) and Carpenter (1913), who consider them to be the homologues of the maxillulae of Crustacea. Crampton, however (1921) considers them to be homologous with the *paragnaths* of Crustacea, which are not true appendages. Folsom's researches (1900) on the embryonic head of the Collembolon *Anourida* show that these lobes arise from embryonic buds situated on the mandibular segment, and placed mesad of the true embryonic mandibles. This agrees with the position of the embryonic paragnaths of Crustacea. Unfortunately, even in some of the latest text-books the statement is repeated that these lobes are true appendages, and the insect head is considered to have seven segments. The author has repeatedly failed to find more than six segments in the embryonic insect head. The question can only be finally settled by a study of the embryo of one of the Machilidae,

this being the family in which these problematical structures are best developed.

In piercing and sucking types, the hypopharynx may combine with the labium to form a single elongated, lance-like organ (e.g. in Diptera). This is called the *labium-hypopharynx*. The opening of the salivary duct is carried right to the tip of this organ, whose function is to inject saliva into the wound while the liquid food (blood) is being carried backwards into the gullet through the mouth proper (fig. W2).

THE THORAX

The thorax (fig. A1), is composed of three segments, called the *prothorax*, *mesothorax* and *metathorax* respectively. Each of these bears a pair of segmented legs, which articulate with the segment latero-ventrally between the pleuron and the sternum. The wings are attached dorso-laterally to the last two thoracic segments, the fore wings arising from the mesothorax, the hind from the metathorax. A small *neck region* is often present connecting the head with the prothorax, and often carries some tiny sclerites, called the *cervical sclerites*.

In the more primitive insects, the three thoracic segments are quite distinct, but in many specialized winged forms the meso- and meta-thorax are closely fused together, forming a single mass called the *pterothorax*. The description which follows applies to any one of the three thoracic segments. To distinguish the parts of one segment from those of another, the prefixes *pro-*, *meso-* and *meta-* are used; e.g., *prosternum* =sternum of prothorax, *mesosternum* = sternum of mesothorax, and *metasternum* = sternum of metathorax, etc., etc.

Each thoracic segment is divided primarily into a dorsal plate or *tergum*, right and left lateral plates or *pleura*, and a ventral plate or *sternum*. Secondary divisions of these occur as follows:—

The Tergum:—In most primitive insects and larval forms, this is formed of a single sclerite, called the *notum* (*n*); in some cases, however, a short posterior sclerite is also developed, called the *postnotum* or *postscutellum*. The notum remains undivided in the prothorax, but in the mesothorax and metathorax of many insects it is divided into a large anterior sclerite, the *scutum*, and a smaller posterior sclerite, the *scutellum*. In some insects having a fused pterothorax and reduced hind wings the scutellum of the mesothorax projects backwards as a strong subtriangular lobe above the metanotum, which it more or less hides (Hymenoptera, Diptera, etc.). The scutum may have a short anterior sclerite separated off from it, called the *prescutum*, or it may be divided by two longitudinal sutures (called *parapsidal furrows*) into a middle portion and two lateral portions or *parapsides*.

In some insects (Hymenoptera, Diptera, Lepidoptera and some Homoptera) there is a small scale-like sclerite attached laterally to the mesonotum, just in front of the base of the costal margin of the wing. This sclerite is called the *tegula* (fig. T6, *tg*). It is sometimes strongly developed so as to overlap the base of the wing, as in the fore wings of many Lepidoptera.

The Pleura:—Each pleuron is normally divided into two sclerites, an anterior *episternum* (*eps*), and a posterior *epimeron* (*epm*). Each of these is sometimes divided into an upper and lower portion. Between the episternum and the base of the leg is a small sclerite, the *trochantin* (not to be confused with the trochanter, p. 19). Sometimes the

episternum of the mesothorax has an anterior portion constricted off, called the *pre-episternum* or *prepectus*.

The Sternum:—In most insects the sternum remains undivided; in some, a posterior portion is separated off, called the *sternellum*. As many as four divisions are recognised in some cases, viz., an anterior *presternum*, followed by a second piece or *eusternum*, a third piece or *sternellum*, and finally a posterior piece or *post-sternellum*. These four divisions occur in some of the more primitive Orders, e.g., Dermaptera.

Spiracles (see p. 32):—Normally there are two pairs of thoracic spiracles, viz., one pair situated between propleurum and mesepisternum, and other between mesepimeron and metepisternum. Sometimes only the former is present; it may appear to be so closely associated with the prothorax as to be called the "prothoracic spiracle." The thoracic spiracles are best spoken of as the "first pair" and "second pair" of thoracic spiracles.

The Legs

A typical insect leg (fig. A1) consists of the following parts:—*coxa* (*cx*) or hip, *trochanter* (*tr*), *femur* (*fm*) or thigh, *tibia* (*tb*) or shank, and *tarsus* (*ts*) or foot.

The *Coxa* is the segment by which the leg is articulated to the thorax; it is usually short and broad, sometimes elongated. The cavity into which it fits is called the *acetabulum* or hip-cavity and is situated between the pleuron and the sternum. The coxa is usually an undivided segment, but in some insects it is divided longitudinally into an anterior piece, called the *true coxa* or *veracoxa*, and a posterior piece, called the *meron*. The meron lies below the epimeron, and a number of authors have considered it to be part of that sclerite; some have confused it with the trochantin.

The Trochanter is a small segment interposed between coxa and femur. Usually it is quite distinct, but occasionally it appears to be only partially separated from the femur. In Odonata and Hymenoptera the trochanter is often more or less distinctly divided into two segments.

The Femur is the strongest part of the leg; it is generally fairly long, and stouter than both trochanter and tibia. It is sometimes armed with stout spines, but never with movable spurs.

The Tibia is generally as long as, or longer than, the femur, but much slenderer. It articulates with the femur by the knee joint, which is freely movable, and usually rests at a marked angle to it. It is frequently armed with one pair, or even two pairs, of movable spurs, called the *tibial spurs*; if only one pair of these is present, they are placed at or near the apex of the tibia (apical spurs); the second pair lies some way from the apex (middle spurs).

The Tarsus:—This is the terminal part of the leg, and consists normally of five distinct segments of very variable length. The first of these is sometimes specialized, differing considerably from the others; it has been called the *metatarsus*, but this term is open to objection. The apical segment is generally furnished with two strong *claws*, which may be simple or toothed internally. Between the claws there is often developed a process called the *empodium* or *arolium* (figs. W6, W7); this is usually a soft pad, but sometimes only a spine or bristle. Below the claws there may also be developed a pair of similar but narrow pads, called *pulvilli*. All three pads are present in some insects (see fig. W6).

Many interesting specializations of the legs occur, of which the following are the most important:—

1. *Raptorial Legs*, specialized for seizing prey, e.g., forelegs of Mantidae (fig. A1) and Mantispidae, hind legs of Bittacidae (see pp. 319, 331).
2. *Saltatorial Legs*, specialized for jumping and springing, e.g., hind legs of Orthoptera Acridioidea and Fleas (see pp. 90, 381).
3. *Fossorial Legs*, specialized for burrowing. All three pairs of legs may be suited for this, but generally the forelegs are the most highly specialized; e.g., legs of Gryllotalpidae and Fossorial Wasps (pp. 97, 292), forelegs of numerous Beetles. Many larvae have fossorial legs, e.g., those of the Cicadidae and Ithonidae (pp. 160, 314).
4. *Natatorial Legs*, specialized for swimming; they have blade-like or paddle-like tibiae and tarsi, often with specialized hairs; e.g., many Coleoptera, pupae of Trichoptera, etc. (pp. 193, 197).

THE WINGS

There are normally two pairs of Wings, the *forewings* being attached to the mesothorax, the *hindwings* to the metathorax.

Each wing developed as a lateral expansion of the notum of the segment to which it belongs (*paranotal expansion*). In the Ectopterygote Insects, the wings appear fairly early in larval life as small buds, which increase in size at each successive instar until they are fairly large, backwardly directed flaps called the *wing-sheaths* or *wing-cases*. At the final ecdysis (metamorphosis) the true wings are withdrawn from their sheaths in the form of soft membranous bags filled with blood; these expand rapidly, thus causing the upper and lower surfaces of the bag to come into contact everywhere except at the veins, where small channels are left. Exposure to the air causes the blood to evaporate, except only in these channels, so that the completed wing appears as a flat membranous expansion strengthened in a number of places by stout ribs called *veins* or *nervures*. In the Endopterygote insects the development is really much the same, but the early stages of growth during larval life are hidden beneath the larval skin, and the completed wing-sheath only appears at the penultimate instar, when the larva changes into a pupa; the final expansion of the wing in the imago is similar to that in the Ectopterygota.

The developing wing-sheath is supplied with a number of tracheae which arise from two tracheal trunks at its base; these trunks are called the *costo-radial* (anterior), and the *cubito-anal* (posterior). The costo-radial trunk gives rise to the costal, subcostal and radial tracheae; the cubito-anal trunk to the cubital and anal tracheae. The median trachea sometimes arises from the costo-radial trunk, sometimes from the cubito-anal.

The *wing-veins*, or *nervures*, are first laid down as pigment-bands in the developing wing-sheath, following the courses of the tracheae. Such bands may occur either on the outer or inner wall of the sheath. If the wing-sheath is normally placed, the bands on the upper wall give rise to *convex veins*, i.e., veins placed on ridges in the completed wing, while the bands on the lower wall give rise to *concave veins*, i.e., veins lying in hollows or furrows. If the larval wing-sheath is turned over, as in Odonata and some Orthoptera, then the upper layers

of pigment give rise to concave veins, the lower to convex veins. The vein itself is formed as a strong arch of chitin deposited over the channel of the trachea at metamorphosis, and generally completed on the opposite side of the channel by a weaker deposit. In certain Endopterygote insects, the vein pigments are deposited before the tracheae grow out into the wing.

The completed wing (fig. XI) of the imago is movably articulated to the side of the notum. Primitively this articulation appears to have been of a simple type, there being a single swelling at the base of the radius, called the *anterior callus*, articulating with a single small sclerite, called the *anterior axillary*, placed behind the tegula, next to a projecting process of the scutum called the *anterior notal process*. This condition is still found in the Plectoptera and Odonata, and appears to be correlated with the primitive method of flight by direct movements of the thoracic muscles. In all other winged insects, however, there is also a *posterior callus* at the base of the anal veins; this articulates with a *posterior axillary*, lying well behind the anterior one, next to a second projecting process of the scutum called the *posterior notal process*. Each of these two axillaries is sometimes further divided into two more or less distinct parts, so that some authors consider that there are four distinct axillaries articulating with the base of a specialized wing.

Beneath the wing, there is generally a more or less prominent process of the pleurum called the *pleural wing-process*, which helps to support the wing from below; on either side of this there is sometimes a small but distinct sclerite, called a *parapteron*.

The membrane of the wing is seldom absolutely smooth, as in Odonata. Usually it carries hairs, either as a marginal fringe or along the veins, or all over the membrane. These hairs are of two kinds, *macrotrichia* or movable hairs, developed from special hypoderm cells, and usually only along the courses of the main veins, and *microtrichia* or fixed hairs, of much smaller size and without sockets, developed uniformly in the cuticle by every unspecialized hypoderm cell below it. In the Trichoptera and Lepidoptera the macrotrichia spread all over the membrane, and the microtrichia are reduced to microscopic *aculeae* (p. 399), or may even disappear. *Scales* (pp. 127, 350, 386, 399) are macrotrichia specialized by flattening and striation; they occur all over the wing in Lepidoptera and some Trichoptera, and also along the veins in some Copeognatha and Diptera.

Wing-Venation

The *Wing-Venation*, or system of veins on the wing, is of the greatest importance in the classification of insects. We owe to Comstock and Needham what is probably the greatest single line of advance ever made in the study of insects, viz., their system of nomenclature and notation for the veins of the insect wing. This system is based on the hypothesis that *the imaginal veins are laid down upon the courses of the preceding tracheae*. From it there arise the two following important conclusions:—

(1) All the Orders of Pterogote Insects have a venational scheme which is basically the same, so that the veins in different Orders can be homologized with one another.

(2) Where the interpretation of the homologies is difficult in the

imago, a reference to the preceding tracheation of the larval wing-sheath will determine the true homologies.

The student should, however, bear in mind that the larval tracheation and imaginal venation have evolved together and reacted upon one another for millions of years, so that (2) is really only strictly true of those Orders in which no specializations have taken place in the tracheational scheme. Thus, while the venational puzzles of the Copeognatha, Homoptera, Neuroptera and Lepidoptera can be solved by reference to the precedent larval or pupal tracheation, which remains generalized, those of the Hymenoptera, Mecoptera, Diptera, and Trichoptera cannot be solved in this manner, but must be worked out by reference to the available fossil representatives or by the methods of comparative morphology.

Another point of great importance is the *convexity* and *concavity* of the veins. Adolph was the first to suggest that convex and concave veins succeed one another alternately in the insect wing. He added to this statement a theory of the origin of veins which Comstock rightly rejected. A study of fossil wings shows clearly enough the importance of the convexity and concavity of the veins, though it also shows that it is only in certain Orders that they alternate regularly.

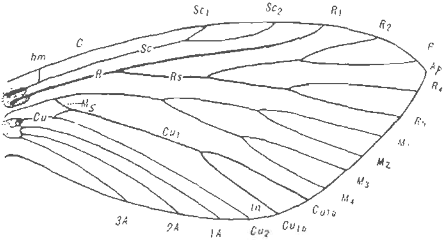


FIG. A8. Hypothetical type of Insect Wing Venation, adapted from Comstock. *Ap*, apex of wing; *1A*, *2A*, *3A*, first, second and third anal veins respectively; *C*, costa; *Cu*, cubitus; Cu_1, first cubitus; Cu_2, second cubitus; *hm*, humeral veinlet; *M*, media; M_1, M_2, M_3, M_4, its four main branches; M_5, its posterior branch, uniting with basal piece of Cu_1 to form the cubito-median Y-vein; *R*, radius; R_1, its main stem; *Rs*, radial sector; R_2, R_3, R_4, R_5, its four main branches; *Sc*, subcosta; Sc_1, Sc_2, its branches; *tn*, tornus.

Comstock has given a hypothetical wing-type (fig. A8), which he claims is the original wing type for the Insecta. A study of the fossil record shows that his claim is justified as far as the main veins are concerned, inclusive of *Rs*, but that it is not justified for the branches. Comstock's system recognizes eight main veins in the wings, as follows:—

Costa (*C*), Subcosta (*Sc*), Radius (*R*), Media (*M*), Cubitus (*Cu*), First Anal (*1A*), Second Anal (*2A*), Third Anal (*3A*).

This scheme is accepted in this book, though it seems doubtful whether three separate anals should be recognized, except as branches of a single original vein.

A special branch of the radius, called the Radial Sector (*Rs*), is a constant in all insect wings, and must also be recognized.

When it comes to further branching, Comstock's hypothetical type is found to be only a central type occurring in the Mecopteroid Orders (see p. 326, footnote). Though the notation suggested by Comstock is very convenient, and will be adopted here, students should be careful to note that this type of branching is only one of three main types. The types of branching are as follows:—

FIG. A9. The three principal types of branching of veins: A, dichotomic; B, pectinate; C, triadic; posterior series.

A. *The Dichotomic type*:—Each vein branches more or less symmetrically into two, without intervention of a third vein of opposite sign (fig. A9, A). This type of branching is confined chiefly to the radius, media and first cubitus of the Mecopteroid Orders (exclusive of Neuroptera).

B. *The Pectinate type*:—The vein gives off a series of more or less parallel descending or ascending branches (fig. A9, B). This is most clearly developed in the radial sector of Neuroptera and some Orthoptera (in the Cockroaches the series is anterior, in all the rest posterior), in the subcosta of many reticulate types, and in the first cubitus in a few cases only. It may arise either from a dichotomic type, or by continuous branching at the apex of the vein, each branch moving basad to make room for another.

C. *The Triadic type*:—This type can be developed from either of the dichotomic or the pectinate type, by interpolation of a vein of opposite kind between each successive pair of branches of the same kind. A *positive triad* is formed by the interpolation of a concave vein between two convex branches, and a *negative triad* by a convex vein between two concave branches. The interpolated vein may be unattached, as in recent Plectoptera, or it may be attached to the vein above it, or the one below it, or to both. If it is attached to both, then it forms a Y-vein. The most important Y-vein is the *cubito-median*, which, by loss of its upper connection with *M*, has become Cu_1 in most cases. (See, however, figs. ZA3, ZA4.) In a triadic system, the alternation of convex and concave veins is complete (see fig. A9, C).

It will be obvious from the above that the interpolated or middle veins in triads are not homologous with any portion of a dichotomic or pectinate series. It is therefore necessary to use a new terminology for them; in this book, the prefix "*I*" is added to the notation for the vein on which the triad is developed; if there is a series of triads, then the prefix "*I*" is added to the notation for the vein just anterior to the interpolated vein to be named. As the Plectoptera and Odonata are the only recent Orders in which triads are extensively developed, reference should be made to chaps. VIII and IX for further explanation.

Using a plus sign (+) to indicate a convex vein, a minus sign (−) for a concave one, the Comstock-Needham scheme may now be exhibited as follows:—

Main Veins and Branches.	Notation.	Main Veins and Branches	Notation.
Costa	C	Media (—)	M
Subcosta (—)	Sc	First Branch	M_1
First Branch	Sc_1	Second Branch	M_2
Second Branch	Sc_2	Third Branch	M_3
Radius (+)	R	Fourth Branch	M_4
Main Stem (+)	R_1	Posterior Basal Branch (uniting with Cu_1)	M_5
Radial Sector (—)	Rs	Cubitus	Cu
First Branch of Rs	R_2	First Cubitus (+)	Cu_1
Second Branch of Rs	R_3	Anterior Branch	Cu_{1a}
Third Branch of Rs	R_4	Posterior Branch	Cu_{1b}
Fourth Branch of Rs	R_5	Second Cubitus (—)	Cu_2
		First Anal (+)	$1A$
		Second Anal (— or +)	$2A$
		Third Anal (+)	$3A$

It should be noted that there are usually two *very strongly developed convex veins* in an insect wing, viz., R_1 and Cu_1. These can generally be picked out at a glance, and the student can then place the rest in order. Concave veins tend to weaken in specialized types, and in many cases may be partially or wholly lost, or partially fused with a neighbouring convex vein. Sc frequently fuses with R_1; M may fuse partially with R, Rs or Cu_1, or its main stem may be lost, as in most Lepidoptera; Cu_2 is often reduced, lost or fused with $1A$.

Lameere has recently shown (1922) that the above scheme of Comstock's is not complete as regards the structure of the media. In most of the Palaeozoic Fossil Insects, and in the recent Order Plectoptera, the media has a *convex anterior branch*, to which we shall give in this book the notation MA, to distinguish it from the *concave posterior branch*, which is Comstock's M in the Table given above. This vein MA is also present in the Odonata, where M itself is absent. The Lower Permian Protorthoptera show a remarkable series of forms in which the evolution of the media parallels that in the Odonata to a great extent, and it seems highly probable from a study of these that the media of many recent Orthoptera will also prove to consist of both MA and M, while the two-branched media of the Perlaria quite probably consists only of MA, with M absent. The researches on Plectoptera and Odonata having been completed, the results are embodied in this book; in the case of the Orthoptera and Perlaria, the old notation is adhered to for the present, but the student should note that it is very doubtful whether it is correct.

Veinlets are short branches of main veins, and are always preceded by a trachea in the larval wing-sheath. The most important are the *humeral veinlet* (fig. A8, *hm*), and the *costal series* of veinlets (fig. U1), of which *hm* is generally the first.

Oblique Veins (figs. F8, F10, *O*) are short veins, obliquely placed, which indicate the position of some tracheational or venational specialization, e.g., the fusion of two veins together or the capture of the course of one vein by a trachea from another.

Cross-veins are transverse struts, rarely preceded by a trachea; they are developed between branches of main veins to strengthen the wing.

All the above are denoted by small letters in italics.

Cells of the Wing:—The closed areas into which the wing-membrane is divided by the veins are called *cells*, or, if very small, *cellules*. In this book, where necessary, cells are designated by small letters in

italics; they differ from cross-veins in that the letters used are taken from the vein bounding the cell anteriorly, whereas for cross-veins the notation is compounded of the two sets of letters indicating the main veins which it connects. (See Table on p. 258.) For special cells, e.g., median cells in Diptera, fig. W8, *mc*, p. 337, the letter *c* may be added to the notation.

The Wing-Margins:—The primitive type of wing is of more or less elongate shape, having an *anterior* or *costal margin* and a *posterior* or *anal margin*. The angle at which these meet distally is the *apex* of the wing (fig. A8, *Ap*). In those cases where the hindwing is specialized by shortening, the forewing tends to become triangular, the original posterior margin becoming divided into a basal *posterior* or *dorsal margin* and a distal *terminal margin* or *termen*. The obtuse angle between these is called the *tornus* (fig. A8, *tn*).

The Anal Area:—This is often sharply divided off from the rest of the wing by a deep furrow, the *anal furrow*, in which, very frequently, vein Cu_2 lies; this vein is then known as the *vena dividens*. The anal area itself frequently becomes wholly convex, with only convex veins upon it, and is then called the *clavus*, the anal furrow being termed the *claval suture*.

Comstock's work (1918) is indispensable for all who wish to study wing-venation fully. The student should, however, notice that the author considers Comstock's determinations inaccurate in the following cases:—

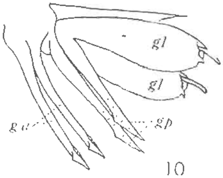
1. In the Plectoptera and Odonata, the alleged crossing of veins *Rs* over the two branches of *M* (Needham and Morgan) does not exist. The tracheal crossing is purely a tracheational specialization, indicated in the imaginal wing by an oblique vein. The true limits of *Rs* and *M* are indicated on pp. 59 and 68.
2. In numerous Orders (especially Hemiptera), Comstock considers, with no apparent reason, that *1A* is a branch of *Cu*. The truth is that his *1A* is Cu_2, while his Cu_2 is a branch of Cu_1. See p. 144.
3. In the Diptera, the veins named Cu_1, Cu_2, and *2A* respectively by Comstock are in reality M_4, Cu_1 and *1A* respectively. Cu_2 is vestigial, in the anal furrow. See p. 338.
4. In the Hymenoptera, the complicated exposition of MacGillivray (1906) is shown by recent fossil discoveries to be incorrect as regards the interpretation of the homologies of *Rs* and *M*, and his incredibly complex "serial veins" do not exist. (See pp. 255-258.)
5. In the Hemiptera-Heteroptera, the positions of *Cu* and *1A* are normal, as in Homoptera. Comstock places the claval suture in front of *Cu*. (See p. 144.)

THE ABDOMEN

The Abdomen consists normally of ten complete segments, of which the first and last are usually considerably abbreviated and frequently have lost their sternites. Vestiges of eleventh and even twelfth segments can be recognized in a few Orders, while the Protura have twelve complete segments. A typical abdominal segment consists of a strongly chitinized dorsal half-ring, the *tergite*, a somewhat less strongly chitinized ventral half-ring, the *sternite*, and between these a soft mem-

branous *pleural region* on either side. This arrangement allows of great mobility in the abdominal segment.

The original segmental appendages of the abdomen are lost in the majority of insects, with the exception of those of the ninth and tenth segments, which will be mentioned later. But, in very primitive insects, such as the Thysanura, they are present as a pair of large *coxites* articulated posteriorly to the sternum; each coxite (which appears to be the homologue of the coxa of the thoracic leg) carries a short appendage called a *style* and also one or two *eversible sacs*. In the males of Plectoptera, the styles of the ninth segment are five-segmented, like the maxillary palp; this may well have been the primitive condition, especially as segmented walking legs are still to be found on the abdominal segments in the newly hatched larvae of Mecoptera and of the Lepidopterous family Micropterygidae. It would also appear to be very probable that the original coxites are included in the ventral sclerite usually designated as the sternite in the higher insects.



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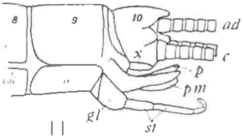

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FIG. A10. Lateral view of dissected ovipositor of the Dragonfly *Synlestes weyersi*, Sel. Australia, (Order Odonata, fam. Synlestidae), to show the three pairs of gonapophyses; *ga*, anterior gonapophysis; *gl*, lateral gonapophysis; *gp*, posterior gonapophysis. [R. J. T. del.

FIG. A11. Lateral view of end segments of abdomen of the Mayfly *Atalophlebia costalis* Burm., male, Australia (Order Plectoptera, fam. Leptophlebiidae), to show gonapophyses and terminal appendages. 8, 9, 10, abdominal tergites; viii, ix, x, abdominal sternites; *ad*, appendix dorsalis; *c*, cercus; *gl*, lateral gonapophysis; *p*, penis; *pm*, paramere; *st*, segmented style. [R. J. T. del.

The Genital Segments:—The external genital organs are, with few exceptions, borne on segments 8 and 9. They consist normally of three pairs of processes called *gonapophyses*, one pair belonging to segment 8 and two pairs to segment 9. They are best studied in the female, where they form the primitive *ovipositor*. With few exceptions, the genital opening or *gonopore* (fig. A12, *gp*), in the female lies in the membrane between segments 8 and 9. The *ovipositor* is formed by two pairs of slender blades enclosed in a pair of broader valves. The first pair of blades is a pair of specially developed processes (not true segmental appendages) from the eighth sternite; these are called the *anterior gonapophyses* (fig. A10, *ga*) or anterior processes. The second pair of blades is a pair of similarly developed processes from the ninth sternite; these are called the *posterior gonapophyses* (fig. A10, *gp*), (posterior processes or inner valves). The gonopore is so situated that the egg, on emerging from it, passes along between these two pairs of processes. Protecting both pairs is a stronger pair of *lateral gonapophyses* (fig. A10, *gl*), (lateral processes or dorsal valves), which are the coxities of the appendages of the ninth sternite; in the Odonata they carry terminal styles. The Plectoptera have no ovipositor, and the gonopore opens

between the seventh and eighth sternite, being protected by a posterior process of the seventh sternite, called the *subgenital plate*. In many of the higher insects, the original ovipositor is vestigial or entirely absent, the last three segments of the abdomen being developed in a telescopic manner, forming a long tube with the gonopore near the end. In these cases, the tubular part of the abdomen itself acts as the ovipositor; sometimes, as in Trichoptera, a pair of small processes close to the gonopore indicate the sole remaining parts of the original ovipositor.

In the males the parts are very different, and not easy to homologize with those of the female. The gonopore opens between the ninth and tenth sternites; it is nearly always carried at the extremity of an elongated *penis* (fig. A11, *p*) or male intromittent organ. In almost all insects, the penis is a median unpaired organ; but in the Plectoptera and some Dermaptera, it is a paired organ with two separate openings; in other Dermaptera, one half of the penis may be vestigial, so that it is a single but asymmetrical organ. From near the base of the penis there are developed a pair of processes called the *parameres* (fig. A11, *pm*); these are outgrowths of the ninth sternite, and can be certainly homologized with the posterior gonapophyses. Besides these the lateral gonapophyses (fig. A11, *gl*), (coxites of the ninth sternite or *gonocoxites*) can easily be recognized in the males of many insects; in a number of cases they carry *styles* (fig. A11, *st*), even when, as in many Orthoptera, the coxites themselves are fused together into a single plate (*hypandrium*) covering the other genitalia from below. The anterior gonapophyses are not normally present in males, but may be found in a few Machilidae, where they are called the *anterior parameres*. The term *aedeagus* is frequently used to indicate the fused penis and parameres, together with any accessory structures developed from them. In those Orders in which the coxites of segment 9 are fused together into a single plate, the term *hypandrium* may be used to denote such a plate.

In the Protura, which have twelve abdominal segments, the male gonopore opens on the eleventh segment. In the Odonata the original penis is aborted and a complicated set of accessory genitalia is developed on the second sternite, including a new penis of complex structure.

The tenth segment of the abdomen seldom has a separate tergite and sternite; usually it is only chitinized on the dorsal half (tergite), or it may be a single completely chitinized ring. It carries a pair of appendages, called the *cerci*, which may be very long, with numerous segments, or very short, with only one or two segments. The cerci are absent in some of the most highly specialized insects.

The *anus*, or terminal opening of the alimentary canal, lies between the tenth tergite and sternite, or, when these are not clearly marked, on a small papilla of segment 10, called the *proctiger*. It is surrounded by three small lobes or processes, viz., the *supra-anal plate* (fig. K1, *cp*) or *telson*, situated dorsally above it, and attached to the tenth tergite, and a pair of latero-ventral *paraprocts* (*pa*). In some insects the supra-anal plate carries a long terminal appendage, called the *appendix dorsalis* (fig. A11, *ad*) or *telofilum*, resembling one of the cerci, but placed dorsally in the middle line; in such cases the abdomen ends in three long, segmented tail-filaments (e.g., some Thysanura and most Plectoptera). In the Dermaptera, the supra-anal plate is divided into four, three or two distinct sclerites, called the *opisthomeres*; these segments may well be the last remains of a reduced appendix dorsalis.

The somewhat difficult terminology and homologies of the end-segments of the abdomen may best be simplified by a statement in tabular form as follows:—

TABLE OF THE END SEGMENTS OF THE ABDOMEN IN MALE AND FEMALE INSECTS.

Segment.	Sclerite.	Appendages, outgrowths, etc.	In Female.	In Male.
8	Sternite.	Anterior Gonapophyses.	= Ventral Valves of Ovipositor.	= Anterior Parameres, in some Machilidae only.
			Gonopore opens between 8 and 9.	
9	Sternite.	Posterior Gonapophyses.	= Inner Valves of Ovipositor.	= Parameres.
		Segmental Appendges:—		
		Coxites (= Lateral Gonapophyses)	= Dorsal Valves of Ovipositor.	= Gonocoxites, or (if fused) Hypandrium.
		Styli	Present only in Odonata and *Mastotermes*.	Present in Plecoptera, Isoptera and many Orthoptera.
				Penis with gonopore between 9 and 10.
			In both Sexes.	
10	Sternite.	Cerci (=segmental appendages). Paraprocts. (Anus opens between tenth sternite and tergite.)		
10	Tergite.	Supra-anal plate or Telson Appendix dorsalis.		

Note:—It is necessary to add here that embryologists claim that vestiges of two extra segments, the eleventh and twelfth, can be found in the abdomen of many insects, and that various interpretations of the telson and paraprocts (and even, by some authors, of the cerci) are given associating them with these segments. A discussion of these difficult problems is beyond the scope of this work.

It may also be pointed out that copulatory organs, known as *claspers*, are developed in the males of many insects, but are not homologous in the different Orders. They may be developed from any of the following parts:—tenth tergite, paraprocts, cerci, coxites of lateral gonapophyses, styles of same. Copulatory hooks, slender rods or "titillators", and other curious structures, may also be developed from these or from the unpaired parts of the terminal segments.

The terms "superior appendages" and "inferior appendages", frequently used by systematists to describe the terminal appendages of insects, are likewise not to be homologized in the various Orders, but indicate terminal structures used in pairing.

Spiracles (see p. 32) :—Normally the abdomen carries eight pairs of *spiracles* (fig. 11, *sp*), situated in the pleural membranes of segments 1 to 8 respectively. There are many variations from this rule, e.g., that of segment 1 may move forward on to the metathorax, or that of segment 8 may be missing. Larval forms of certain Orders show many extraordinary conditions (see Diptera, p. 342).

CHAPTER III

INTERNAL MORPHOLOGY

SPACE will not allow us to deal adequately with all the complex internal organs of the Insecta. Though of great morphological interest, they are little used by systematists, owing to the greater difficulties in studying them as compared with the external characters offered by the dried insect. A number of excellent Text-books on general insect morphology have recently been published, and are included in the list of references at the end of this chapter. Students would be well advised to read at least one of these books thoroughly in conjunction with this work.

THE BODY-WALL AND MUSCLES

The *Body-wall* of an insect consists of three parts:—

1. The *cuticle*, a non-cellular layer of chitin.
2. The *hypodermis*, a single layer of living cells, which secrete (1).
3. The *basement membrane*, a very delicate membrane underlying (2).

The *Muscles* are formed of bundles of *muscle-fibres*, which differ from those of Vertebrates in not possessing a surrounding sheath or myolemma. These fibres are of the striated type. They may be attached directly to the body-wall, or to a special ingrowth of the same, called an *apodeme* (p. 11). Most of them have no tendons, but some of the muscles of the appendages are inserted by means of ligamentous tendons, while some of the thoracic muscles originate from large cup-like or conical tendons formed of chitin; these latter are evidently specialized parts of apodemes.

Space will not allow of a detailed account of the immense number of muscles in an insect's body; if required, reference should be made to Berlèse, *Gli Insetti*, and to other works on Insect Morphology.

THE ALIMENTARY AND EXCRETORY SYSTEMS

The Alimentary System proper begins at the mouth and includes the organs of mastication, already dealt with on pp. 15-18. The posterior part of the mouth is called the *pharynx* (fig. A12, *ph*); it is bordered above by the epipharynx and below by the hypopharynx. It passes by a circular opening into the *oesophagus* (fig. A12, *oe*) or gullet, which is a long slender tube passing obliquely between the connectives of the brain (through an opening in the tentorium), and continued through the thorax into the anterior part of the abdomen. Its posterior portion is

enlarged into a more or less capacious *crop* (fig. A12, *cr*). In a number of insects which require to triturate their food thoroughly, there is attached to the posterior end of the oesophagus a strongly muscular chamber called the *gizzard* (fig. A12, *gz*), which may be provided intern-

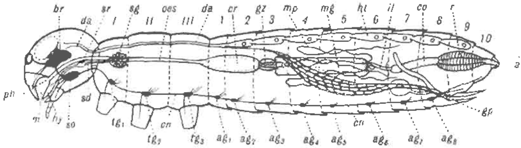


FIG. A12. Diagrammatic lateral view of internal organs of an insect to show (*a*) alimentary and excretory system; (*b*) circulatory system; and (*c*) central nervous system. *I, II, III*, the three thoracic segments; 1-10 the ten abdominal segments. ag_1-ag_8, the eight abdominal ganglia; *an*, anus; *br*, brain; *cn*, connectives; *co*, colon or large intestine; *cr*, crop; *da*, dorsal aorta; *gp*, gonopore; *gz*, gizzard; *ht*, heart; *hy*, hypopharynx; *il*, ileum or small intestine; *m*, mouth; *mg*, midgut; *mp*, Malpighian tubule; *oes*, oesophagus; *ph*, pharynx; *r*, rectum; *sd*, salivary duct; *sg*, salivary gland; *so*, suboesophageal ganglion; *sr*, salivary reservoir; tg_1-tg_3, the three thoracic ganglia. The left ovary, full of eggs, is shown unlabelled, with the duct opening at the gonopore (*gp*); see fig. A16. [*R. J. T. del.*

ally with a complicated array of grinding ridges or separate teeth. The crop is sometimes separated off from the oesophagus, opening into it by a narrow duct.

All the above parts together constitute the *foregut*, which is formed in the embryo from an invagination of the ectoderm (or outermost of the three embryonic layers); the *stomodaeum* (fig. A19, *st*) is the original opening of this invagination; later on, it becomes the *mouth*.

The foregut opens by means of the *oesophageal valve* into the *midgut* (fig. A12, *mg*), also called the stomach or chylific ventricle, which is the digestive portion of the alimentary canal. This is usually a more or less elongated sac lined internally with an epithelium of large cells which secrete the digestive fluids. These cells are protected from damage by contact with solid particles of food by a *peritrophic membrane* which forms at its interior end and descends like a sleeve around the food, passing out with the faeces. The midgut may be simple, or it may be provided with one or more diverticula or side-chambers, called the *gastric* or *hepatic caeca*.

The Salivary Glands (fig. A12, *sg*) are a pair of small but complex glands, usually situated in the prothorax, which are connected anteriorly with a pair of slender *salivary ducts* (*sd*); these latter unite and open by a common duct at the base of the hypopharynx. *Reservoirs* (*sr*) for holding the saliva are present, either as enlargements of the ducts, or as separate chambers, having their own ducts.

The midgut constitutes the middle division of the alimentary canal, and is formed in the embryo from the endoderm, or innermost of the three embryonic layers.

The junction of the midgut with the anterior end of the hindgut is marked by the entry of the principal *organs of excretion*, known as the *Malpighian tubules* (*mp*). These are slender, delicate tubules, very variable in number, lying freely in the body cavity; their function is to extract uric acid from the blood. The original number of these tubules was probably *six*, but reductions to five, four, three or two are known

to occur. In some Orders the number is increased to fifty or more, but the number of separate openings remains six.

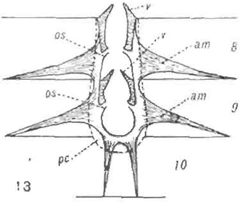
Systematists have made use of the number of Malpighian tubules in classifying the Orders; those with few tubules are called *oligonephric*, those with many, *polynephric*. The polynephric Orders are Plectoptera, Odonata, Orthoptera, Perlaria, Dermaptera and Hymenoptera. The Thysanura are variable, ranging from 0 in Japygidae to 20 in some Machilidae.

In some larvae (Planipennia and a few Coleoptera) some of the Malpighian tubules are specialized for the production of silk, which is spun from the anus.

The *hindgut* is generally divided into three portions; the *ileum* or *small intestine* (*il*), just posterior to the Malpighian tubules, and very narrow; the *colon* or *large intestine* (*co*) following it (frequently these two are not differentiated from one another); and the *rectum* (*r*), a large, swollen chamber provided with six strong bands of longitudinal muscle. The rectum opens into the *anus* (*an*) or posterior opening of the alimentary canal, lying between the tenth tergite and sternite.

The whole of the hindgut, forming the posterior division of the alimentary canal, is formed in the embryo from an invagination of the ectoderm, the mouth of the invagination being the *proctodaeum* (fig. A19, *pr*), which, later on, becomes the *anus*.

Organs of Excretion. The most important of these are the *Malpighian tubules*, already dealt with above. Besides these, the *pericardial cells*, situated on either side of the heart, are known to extract uric acid from the blood, while the large cells called *oenocytes*, developed in connection with the fat body and tracheal system, store up uric acid and other excretory products. Many waste products are also excreted through the hypodermis and the chitinous cuticle.



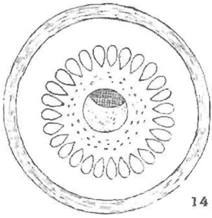


FIG. A13. Last two chambers of an insect's heart, dorsal view: *am*, alary muscle; *os*, ostium; *pc*, pericardial space; *v*, valve; *8-10*, abdominal segments. [*R. J. T. del.*

FIG. A14. Highly specialized spiracle from abdomen of the Scorpion-fly *Chorista australis* Klug., last larval instar; this spiracle is a circular disc with a raised rim and carries a circular grating with 27 openings. [*R. J. T. del.*

THE RESPIRATORY SYSTEM

The Respiratory System of insects consists of a series of air-tubes or *tracheae* ramifying throughout the body. The openings of this system are a series of *spiracles* (figs. A1, A14), sometimes called *stigmata*; of these there are normally ten pairs, two thoracic and eight abdominal (see pp. 19, 29). A spiracle is normally a small round hole or

opening in the cuticle having a thickened rim or *peritreme*, leading into a small chamber, the *atrium*, from which one or more tracheae pass inwards into the body. Each spiracle is provided with a closing apparatus, and often also with brushes of hairs to keep out dust. Many specialized forms of spiracles occur, some of which are of use in systematic work (fig. A14).

Each trachea consists of a delicate, flexible tube formed of a single layer of epithelial cells supported externally on a fine basement membrane. Internally these organs secrete a delicate chitinous layer or *intima*, on which are developed spirally formed thickenings, known as the *spiral thread*. This spiral thread is cast off with the intima through the spiracles at each ecdysis.

In most insects some of the main tracheae unite to form longitudinal trunks running the whole length of the body through the neck into the head. Two large *dorsal trunks* are generally present, sometimes also *ventral* and *visceral trunks*.

The tracheae branch and re-branch in a complicated manner, finally giving off fine *tracheoles* which end in tiny *capillaries* passing to every set of cells in the body. These capillaries are intra-cellular, i.e., formed within a single cell, and have no spiral thread.

THE CIRCULATORY SYSTEM

In the Insecta there is only a single closed vessel carrying the blood; it is known as the *dorsal vessel* or *heart* (figs. A12, A13), and lies mid-dorsally in the second to ninth abdominal segments. Normally it *consists of eight chambers, each opening into the one before it by a* pair of valves; the last chamber is closed behind. Each chamber has a pair of openings, one on each side, called *ostia*, through which the blood enters from the body cavity; each ostium is supplied with a valve. Anteriorly the heart is prolonged into a narrow tube, the *dorsal aorta* (fig. A12, *ao*) which runs through the thorax into the head, opening above and in front of the brain.

The heart is supported by a series of delicate, fan-shaped *alary muscles* arising from the dorso-lateral walls of each segment and attached to the heart along its mid-ventral line. The whole set of eight pairs of alary muscles, with their connecting membrane, forms the *dorsal diaphragm*.

The rest of the circulatory system is formed by the general body cavity, which is a *haemocoele* or enlargement of the blood spaces.

The *blood* of insects consists of liquid *plasma* carrying various types of blood-cells in it; of these the most important are the *phagocytes* or *leucocytes*, analogous to the white corpuscles in the blood of vertebrates. No red corpuscles are ever present, the function of aëration of the tissues being carried out by the tracheal capillaries. The blood is usually a more or less colourless fluid, often greenish or yellowish; rarely it is bright red, as in the larvae of Chironomidae, owing to the presence of haemoglobin.

The heart contracts segmentally from behind forwards, so that the blood is drawn in through the ostia and passes forward to the head. On leaving the aorta, it divides into two streams, passing downwards and then backwards ventrally to the neck and thorax, and then ventrally backwards along both sides of the abdomen. It also circulates in the appendages.

The haemocoele, or general body-cavity in which the blood circulates, is bordered by large masses of fatty tissue, called the *fat-body*. In many insects, especially in larvae, the fat-body is the most conspicuous mass of tissue in the abdomen; it is held in position by numerous tracheal branches, which enter it in all directions.

The principal function of the blood appears to be the reception of the digestive products from the intestine. The nutritious products are stored in the fat-body, to be drawn upon when needed, while the useless material, chiefly uric acid, is extracted from the blood by the Malpighian tubules. The blood also supplies nutriment to the tissues when needed, and is undoubtedly the final medium in the transference of oxygen to the tissues from the capillaries. It must also play an important part in the removal of carbonic acid gas, about which little is known in the Insecta.

THE NERVOUS SYSTEM

The *Central Nervous System* in Insects consists of the *Brain*, or *Supra-Oesophageal Ganglion* (fig. A12, *br*), the *Sub-Oesophageal Ganglion* (*sg*), and a series of *paired ganglia* (fig. A12, *tg, ag*) situated ventrally in the thorax and abdomen; all these are connected by a pair of longitudinal nerves called *connectives*. Normally there are three pairs of thoracic ganglia, one for each segment, and eight pairs of abdominal ganglia, one in each of the first eight segments. Many specializations occur, the first abdominal ganglion often passing up into the thorax and fusing with the metathoracic ganglion; sometimes all three thoracic ganglia fuse into a single mass; the abdominal ganglia may all be placed close together, or even drawn up into the thorax and fused with the thoracic ganglia.

The composition of the Brain and Suboesophageal ganglion is dealt with on p. 13.

From each ganglion of the central system, nerves pass out to the heart, the segmental muscles and other organs.

Just above the central nervous system, in the abdomen, there is a delicate layer of muscles called the *ventral diaphragm*, somewhat similar to the dorsal diaphragm (p. 33) in structure.

The *sympathetic nervous system* arises from the tritocerebrum. It consists of two parts, the frontal system and the oesophageal system; these supply nerves to the front of the head, the pharynx and the oesophagus.

An obscure *ventral sympathetic nervous system* also exists in connection with the abdominal ganglia, and there is also a *peripheral nervous system* supplying the sensory hairs of the cuticle.

THE SENSE ORGANS

Organs of Sight

The Compound Eyes:—It has already been stated (p. 13) that each compound eye consists of a large number of separate eye-elements or *ommatidia*. A single ommatidium is an elongated, slender eye-element made up of the following parts, from without inwards:—

(a) the *corneal lens* (fig. A15, *cnl*) which is the cuticular part of the eye; it is hexagonal in shape, with convex surface.

(b) the *corneagen cells* (fig. A15, *cng*) or hypoderm cells which secrete the corneal lens.

(c) the *crystalline cone* (fig. A15, *pc*); this may be formed of four separate cells filled with a refracting fluid (*pseudocone type*), or the cell-boundaries may be lost, so that a single cone results (*eucone type*). The nuclei of these cells are called *nuclei of Semper* (fig. A15, *ns*).

(d) the *pigment cells* (fig. A15, *ir*, *rp*) surrounding (c) and (e); the former are called iris pigment cells, the latter accessory pigment cells.

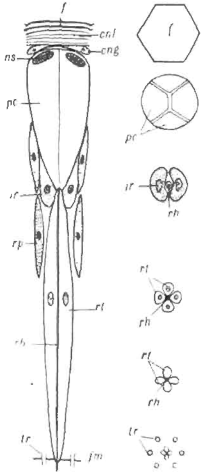


FIG. A15. Longitudinal section through ommatidium of a compound eye of pseudocone type, with series of transverse sections through same at different level. *cng*, corneagen cells; *cnl*, corneal lens; *f*, facet; *fm*, fenestrate membrane; *ir*, iris pigment cells; *ns*, nucleus of Semper; *pc*, pseudocone; *rh*, rhabdome; *rp*, retinal pigment; *rt*, retinal cell; *tr*, trachea. (*R. J. T. del.*

(e) the *retinula* (fig. A15, *rt*) a set of seven or eight elongated retinal cells united longitudinally to secrete a central visual rod or *rhabdome* (fig. A15, *rh*) and continuous posteriorly with the nerve fibres leading to the optic ganglion.

(f) the *fenestrate membrane* (fig. A15, *fm*) forming the inner boundary of the eye.

The most generally accepted theory explaining the method of vision of the compound eye is that known as the *Theory of Mosaic Vision*, formulated by J. Müller in 1826. If a long cylindrical tube be coated internally with blacking, the only light which will traverse it will be those rays parallel to its long axis; all oblique rays will fall on the sides of the cylinder and be absorbed by the black pigment. If the tubes be made very numerous, long and narrow, placed very close together like the ommatidia of the compound eye, each separate unit will only perceive a very small portion of the total field of vision. Thus the complete picture presented to the mind of the insect will be in the form of a *mosaic* of tiny hexagonal pieces, all fitting closely together. Such a type of vision may not be as good as that given by the Verte-

brate eye for distinguishing the *form* of fixed objects; but the slightest *movement* at any point in the field of vision will be at once registered by a change in one or more pieces of the mosaic. It is well known that insects perceive movements much more clearly than they do form, and this theory offers a reasonable explanation of the fact.

The Ocelli:—The number and position of these has been already stated on p. 13. A *lateral ocellus* consists of the following parts:—

(a) a single *corneal lens*.
(b) a corneagen layer of cells which secretes (a).
(c) a retinal layer of cells corresponding with (e) of the compound eye, but very numerous, and containing a considerable number of rhabdomes formed at the longitudinal union of groups of two, three or four retinal cells.

The *median ocellus* is of similar structure, but formed by more or less complete fusion of two originally separate ocelli.

Organs of Sound and Hearing.

The most important of these are as follows: —

(a) the *sound-producing organs* found in various insects, such as Cicadas, Grasshoppers and Crickets. These are described in the sections dealing with these insects (see pp. 95, 97, 160).
(b) *ears* for the receptions of sounds produced as above. These are areas of taut membrane of considerable size, which are made to vibrate by large volumes of sound. Such organs occur in the Grasshoppers and Crickets (see pp. 95, 97).
(c) *Chordotonal Organs*:—These are minute organs for the detection of delicate waves of sound. They are of many diverse forms, but all agree essentially in consisting of a specialized nerve-cell containing a tiny rod capable of vibrating in response to a suitable stimulus. Frequently such an organ is developed in contact with a minute auditory disc or pit in the integument. The vibration received by the disc or pit is transferred to the rod and thence to the nervous system.

    Very complicated chordotonal organs are developed in conjunction with the ears of Grasshoppers and Crickets, but their structure need not be described here.
(d) *Johnston's Organ*:—This is a complex system of nerve cells found in the pedicel of the antenna, and believed to be chiefly auditory in function. The separate cells composing it have a structure analagous to that of a chordotonal organ.

Organs of Taste and Smell.

Smell being only "taste at a distance", the organs which supply these senses in Insects may be considered together. They are all very minute. and are found on the antennae, the legs and many other parts of the body, as well as being abundant on the softer portion of the mouth-parts. Their essential parts are a soft cuticular structure, usually a plate carrying a pore, or a small sensory cone, a nerve-ending in contact with it, and a gland-cell to supply moisture. The cuticular part of the organ is produced by a specialized hypoderm cell, or by several such cells similar to the trichogen cells described on p. 37.

Organs of Touch.

These are the simplest of all the sense-organs, and are known as *tactile hairs* or *sensillae*. They occur on all parts of the integument, including the appendages. The essential parts of such an organ are:—

(a) a specialized hair or seta, placed in a socket, and more or less mobile.

(b) a specialized hypoderm cell called a *trichogen cell*, which produces the seta, or a set of such cells having the same function.

(c) a nerve-ending in contact with the seta, either by passing up into its lumen, or by contact with a delicate membrane in the socket.

It should be noted that the *antennae*, which have been dealt with on p. 14, are composite sense-organs which combine the functions of touch, smell and hearing; probably also they are capable of receiving numerous vibrations not perceivable to our ordinary senses.

THE REPRODUCTIVE SYSTEM

The essential parts of the internal reproductive system are:—

(a) the *gonad* or organ which produces the reproductive cells. The gonad of the female is the *ovary* (fig. A16, *ov*), producing mature female germ cells or *ova*; that of the male is the *testis* (fig. A17, *ts*), producing active male cells or *spermatozoa*. Each insect has two gonads arranged latero-dorsally below the heart.

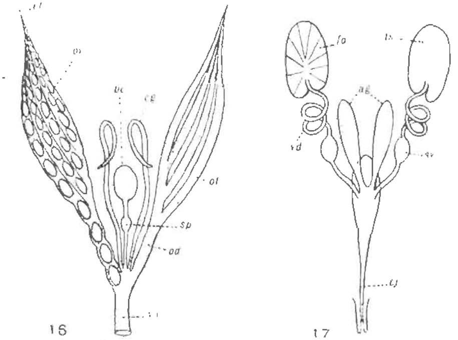


FIG. A16. Diagram of internal reproductive system of a female insect, dorsal view; *bc*, bursa copulatrix; *cg*, colleterial glands; *ef*, end-filament; *od*, oviduct; *ot*, ovarian tube; *ov*, ovary; *sp*, spermatheca; *va*, vagina. [*R. J. T. del.*

FIG. A17. Diagram of internal reproductive system of a male insect, dorsal view; *ag*, accessory glands; *ej*, ejaculatory duct; *fo*, follicle; *sv*, seminal vesicle; *ts*, testis; *vd*, vas deferens. [*R. J. T. del.*

(b) the *gonoducts* or ducts leading from the gonads to the genital opening. They generally unite to form a *common duct* before reaching the opening. In the female, the gonoducts are called *oviducts* (fig. A16, *od*), and the common duct

the *vagina* (fig. A16, *va*). In the male, the gonoducts are called *vasa deferentia* (fig. A17, *vd*), and the common duct the *ejaculatory duct* (fig. A17, *ej*), opening at the end of the *penis*.

(c) the *gonopore*, or genital opening (see p. 26).

(d) accessory internal structures, viz., in the female, the *spermatheca* (fig. A16, *sp*) or sperm-sac, for storing the sperm, the *bursa copulatrix* (fig. A16, *bc*) or copulatory pouch, and the colleterial glands (fig. A16, *cg*) for the secretion of a sticky fluid used in laying the eggs. In the male, there are *accessory glands* (fig. A17, *ag*) which probably secrete the seminal fluid, and sometimes there are enlargements of the vasa deferentia, called *seminal vesicles* (fig. A17, *sv*) for the storage of spermatozoa.

In some insects the female lays her eggs in a mass covered over with sticky material which hardens in the air; such a mass is called an *ootheca* or egg-capsule. In others, the males produce their spermatozoa in solid bundles enclosed in a sac for transference to the female; such a sac is called a *spermatophore*.

Structure of the Gonads:—The ovary is formed of a variable number of egg-tubes or *ovarian tubes* which are attached to the peritoneal membrane below the heart by means of a delicate *end-filament*. The ovarian tube itself contains both germ-cells and yolk-cells, and is classified into three types according to the arrangement of these, as follows:—

(a) *panoistic*, in which the germ-cells occur without interruption from one end to the other, each becoming surrounded with a mass of yolk and a membrane as it passes downward.

(b) *polytrophic*, in which a group of special yolk-cells, called nurse-cells, attaches itself to the anterior end of each germ-cell as it passes downward, so that germ-cells and groups of nurse-cells alternate in the tube.

(c) *telotrophic*, in which the upper or anterior end of the tube is entirely filled with nurse-cells, the germ-cells being produced lower down; in this case, the nurse-cells all combine to supply the yolk to each egg by means of a fine thread-like tubule passing from the nutritive chamber to the egg.

These types have been made use of in systematic and phylogenetic work. It is clear that (a) is the most primitive type, and that both (b) and (c) can be derived from it, but neither of these from the other.

The *testis* is a closed capsule which is divided internally into a series of chambers or *follicles* (fig. A17, *fo*) in the walls of which are the germ-cells which develop into the ripe, active spermatozoa.

For References, see end of Chap. IV.

CHAPTER IV

LIFE HISTORY

The complete life-cycle of an insect is generally passed through in one year, though many cases are known in which two or more complete broods occur in a year, while in others the cycle may be lengthened to last two, three or more years.

The life-cycle may be divided up as follows:—

1. the *egg*, or embryonic stage.
2. the *larva*, or growing stage.
3. the *pupa*, or resting stage.
4. the *imago*, or sexually adult stage which is usually winged.

The pupa, or resting stage, is only found in those highly specialized insects called Endopterygota or Holometabola.

THE EGG

The *Egg* consists of the fertilized *ovum* or female germ-cell, having a large mass of *yolk* enmeshed in its viscid cytoplasm, the whole being enclosed within a delicate *vitelline membrane*, which, again, is covered by the tough egg-shell, called the *chorion*. This shell is made of a

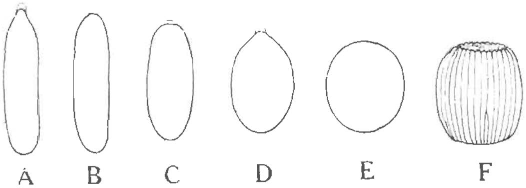


FIG. A18. Types of Insect Eggs. A, primitive elongate oval type from Zygopterid Dragonfly; B, elongate oval egg of Dipteron; C, elongate oval egg of Neuropteron, with raised micropylar area; D, broadly oval egg of Libellulid Dragonfly; E, spherical egg of Hepialid Moth *Charagia*; F, ribbed egg of Butterfly *Erebia butleri*. [*R. J. T. del.*

peculiar substance called *chorionin*, allied to chitin. At the anterior end of the egg the chorion is perforated by a tiny opening known as the *micropyle*, only large enough to allow of the entry of a single sperm. Many eggs have special structures on the chorion protecting the micropyle, such as a raised disc or lobe. The chorion itself is often ribbed or sculptured in an intricate manner, but in most cases it is

smooth, or only bears traces of the somewhat hexagonal pattern impressed upon it by the cells which form it.

The most primitive type of egg in the Insecta was elongate oval in shape, probably also with the dorsal and ventral sides slightly different in curvature. More rounded eggs, broadly oval, spherical or even flattened, and many bizarre, sculptured forms, occur frequently in the higher groups, but all begin as oval forms far up in the ovarian tube.

It should be noted that the term *ovum*, meaning the completed egg as laid by the female, and used commonly thus by many entomologists (especially Lepidopterists) is biologically incorrect and should be discontinued.

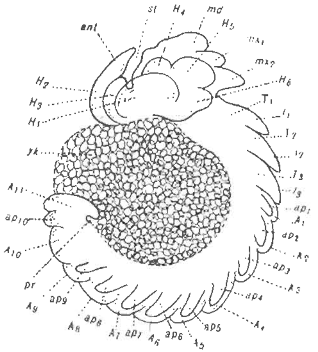


FIG. A19. Embryo of Scorpion-fly *Chorista australis* Klug., removed from egg-shell, 45 hours old, at stage showing formation of segments and appendages, lateral view (x 60). A_1-A_{11}, the 11 abdominal segments; ap_1-ap_{10}, the 10 pairs of abdominal appendages; *ant*, antenna; H_1-H_6, the 6 head segments; l_1-l_3, the 3 pairs of legs; *md*, mandible; mx_1, first maxilla; mx_2, second maxilla (when fused = labium); *pr*, proctodaeum; *st*, stomodaeum; *yk*, yolk. (*R. J. T. del.*

The details of Embryology cannot be given here, but the following points should be noted:—

1. In the Odonata, Lepidoptera and certain Orthoptera, Hemiptera, Anoplura and Coleoptera the embryo is first formed head downwards on the ventral side of the egg, and later on turns round on itself dorsally, rupturing the amnion or covering membrane, and moves forward until the head comes to rest at the anterior end of the egg. In other insects this manoeuvre does not take place, but the embryo is often so much longer than the egg that it is frequently much coiled on itself.
2. In all embryos the head forms first as a series of separate embryonic segments, six in number, and the appendages of these segments (antennae, mandibles, first and second maxillae) are not noticeably different from the thoracic appendages or legs.

3. In almost all embryos, there is a stage in which paired buds, the rudiments of embryonic appendages, occur on *all* the segments, including those of the abdomen (fig. A19). Usually these latter disappear, except the cerci, but in Mecoptera, Lepidoptera, and some others (apparently not in Sawflies) they persist and form the abdominal legs or so-called "prolegs" of the larva.

THE LARVA

The growing period, or larval stage, embraces generally the longest period of an insect's life, and is divisible into a number of stages or *instars*, separated by the act of casting the skin, or *ecdysis*. The number of instars is greatest in the Plectoptera and Odonata, where it ranges from eleven to more than twenty. In other Orders it rarely exceeds six, and is sometimes reduced to four or even three.

The process of hatching is usually rapid, and is brought about by pressure from the swelling head of the embryo forcing the cap of the egg off.

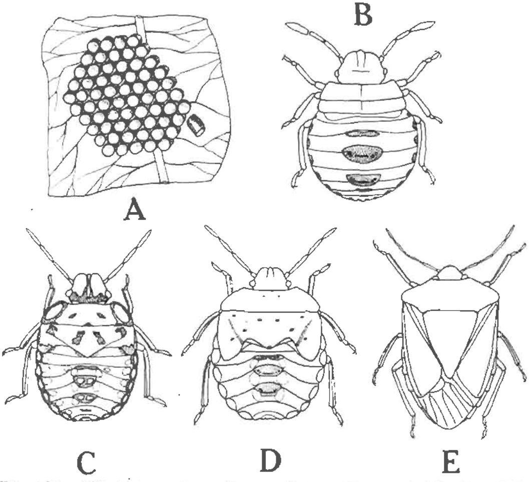


FIG. A20. Life history of the Pentatomid Bug *Nezara viridula* L., (Order Hemiptera). A, the egg; B, the first larval instar, newly hatched; C, third larval instar, with developing wing-buds; D, last larval instar, with well-developed wing-sheaths; E, imago. Note the changes in relative size and form of antennae and legs; also the development of the dorsal abdominal scent-glands in the larva. [*A. Tonnoir del.*

In some Orders, e.g., Odonata and certain Orthoptera, the young larva hatches out as a swathed, inactive *pronymph* which casts its skin almost immediately and becomes an active larva.

In the Apterygota all the larval stages are closely similar, and only differ from the imago in not being sexually mature.

In the Hemimetabola, the wing-buds appear at an early stage, generally at the second, third or fourth larval instar, and increase gradually in size to the last instar, where they are large and conspicuous flaps. Usually the sheaths of the forewings overlie those of the hind, but in the Odonata and Orthoptera Acridioidea, the hindwings more or less overlie the fore. The final ecdysis produces a more marked change than the others and is called the *metamorphosis*. At this moult, the sexually mature and fully winged imago is produced.

The three Orders Plectoptera, Odonata and Perlaria have their larvae specialized for an aquatic life, and the change at metamorphosis is somewhat more marked than in the case of the terrestrial Hemimetabola. These larval forms have been distinguished as *naiads*. A similar marked increased change at metamorphosis is observable in those types having burrowing larvae, such as Cicadas, and in certain other Homoptera.

Hemimetabolous larvae are frequently termed *nymphs*, but the term is not a very suitable one. Biologically the term "larva" means an immature stage which differs sufficiently from the adult animal to require a marked change or *metamorphosis* before attaining that condition. This definition applies equally well to larvae of both Hemimetabolous and Holometabolous insects, and the attempt to restrict the term larva to the early stages of the latter seems both unscientific and unnecessary.

The larvae of Holometabola differ from those of Hemimetabola chiefly in having the wings developed internally within the larval cuticle, instead of as external wing-sheaths increasing in size at each ecdysis. It is only at the metamorphosis of the full-grown larva into the pupa that the wing-sheaths at last become exposed.

The principal types of Holometabolous larvae are (a) *campodeiform*, or *caraboid*, i.e., active, with well developed head, strong legs, more or less elongate cylindrical body, and usually *with* cerci; (b) *eruciform*, or caterpillars, having a soft cylindrical body, well-developed head, but short thoracic legs which are usually aided in progression by the presence of short abdominal "pro-legs"; (c) *melolonthoid*, or scarabaeoid, curved whitish grubs with head and legs, but without pro-legs; (d) *vermiform*, or maggots, with whitish, soft body, head reduced or apparently absent, legs absent, and body often tapering anteriorly. Many other intermediate types also occur. In some cases, the young larva hatches out as type (a), and at the next instar changes to a more specialized type, such as (d). Such an occurrence is called *hypermetamorphosis*; the best known cases are those of the larvae of Cantharidae and Mantispidae (fig. U13).

The type of metamorphosis undergone by the Hemimetabola is called an *incomplete metamorphosis*. Contrasted with this, we have, in the higher Orders of insects, or Holometabola, the interpolation of a pupa or resting stage before the imaginal stage. This type of metamorphosis is known as a *complete metamorphosis*.

THE PUPA

The most primitive type of pupa is the *pupa libera* (fig. A21, E) in which all the appendages are more or less free, and the pupa closely resembles the imago in all except the unexpanded wings and the lack

of colouring. Such pupae occur in Hymenoptera, Mecoptera, Neuroptera, Trichoptera, most Coleoptera, some Diptera and also in the Lepidopterous Micropterygidae. They are capable of moving about, some

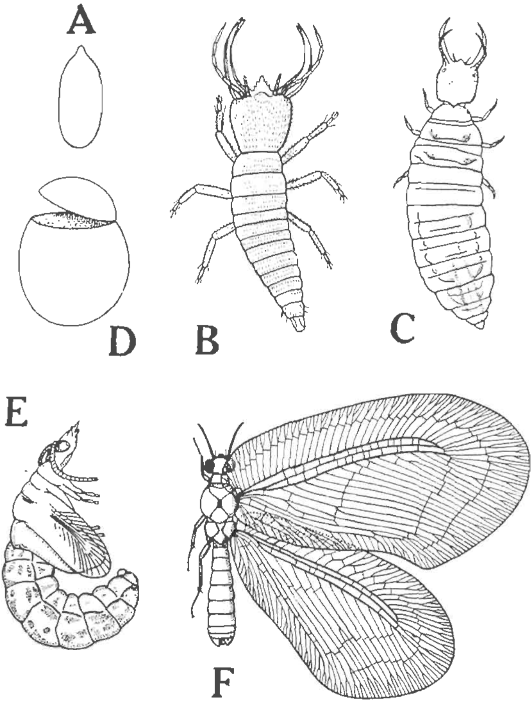


FIG. A21. Life history of the Australian Silky Lacewing, *Psychopsis elegans* Guer., Order Neuroptera. A, the egg, with raised micropylar area, length 1 mm.; B, first larval instar, newly hatched, length 2.7 mm.; C, third (last) larval instar, full-fed, length 12 mm.; D, cocoon, with lid raised, length 6.5 mm.; E, pupa (a pupa libera) removed from cocoon, length 10 mm.; F, imago, with colour-pattern, legs of right side and wings of left side omitted; length of forewing 18 mm. The three strong parallel veins on each wing are Sc, R, and Rs. For colouring of imago, see pl. 11, fig. 19. Second larval instar (similar to third) omitted. [*R. J. T. del.*

of them cutting their way out of the cocoon and climbing a considerable distance before disclosing the imago. In the *pupa incompleta* (figs. W18, Z14) found in many Diptera, the older forms of Lepidoptera,

and some Coleoptera, the appendages are soldered to the body, but remain enclosed in complete sheaths, while the abdomen still retains considerable freedom of movement. The highest type of pupa is the *pupa obtecta* (figs. Z16, Z56-58, etc.), found in the higher Lepidoptera, in which the appendages are completely soldered down and covered over by external plates only, and all parts are immobile except segments 5-6 of the abdomen, or sometimes segment 5 only.

In the Diptera and some Coleoptera *pupae incompletae* are also found, while the higher Diptera are specialized in another direction, pupating within the hardened larval skin, which forms a barrel-like *puparium* (see p. 343); such a pupa is called a *pupa coarctata.*

The pupae of Mecoptera, Neuroptera, Megaloptera, nearly all Coleoptera and Diptera and some Trichoptera and Lepidoptera are not enclosed in a cocoon, but lie in an earthen cell or free on the ground or in other suitable places. Those of many Trichoptera, most Lepidoptera and the Dipterous family Mycetophilidae are enclosed in a silken *cocoon* spun from the mouth of the larva; the silk is produced as a viscous fluid in special silk-glands, whose ducts unite to open on the labium, and is spun as a fine thread which hardens in contact with air. Those of the Neuroptera Planipennia and a few Coleoptera are enclosed in a silken cocoon spun from the anus (see p. 32).

METAMORPHOSIS

The act of metamorphosis takes place, in Hemimetabolous insects, at the ecdysis from the last larval instar into the imaginal stage; in the Holometabola, however, the metamorphosis is begun when the full-fed larva changes into the pupa, and is completed when the pupa discloses the imago. The striking external changes consist of the splitting of the larval or pupal skin, the gradual extrusion of the soft or *teneral* imago (or pupa), and finally the hardening of the integument and appendages, and the expansion of the wings. The wings are at first small bags filled with fluid; as they expand, the two sides of the bag come closer and closer together, and finally fuse everywhere except along the courses of the veins, where channels are left for the passage of tracheae, nerves and blood. The rate of expansion of the wings varies with different insects, but it is always rapid enough to be watched with great interest. Preceding these external changes there is an internal metamorphosis which begins long before the actual ecdysis, and, in the case of the Holometabola, continues throughout pupal life; in the highest types it involves the histolysis or breaking up of all the larval tissues except the mid-gut, tracheal and nervous systems, and their rebuilding into the imaginal tissues from groups of special cells called the *imaginal buds*.

THE IMAGO

The last instar, or *imago*, is the adult insect, and differs from all earlier instars in being sexually mature and usually in being fully winged. A few cases of *paedogenesis*, or production of young by larval forms, are known, notably in the Cecidomyiidae.

The Plectoptera differ from all other insects in having two fully winged stages. The first of these is called the *subimago*, the second the *imago*. The former has dull, opaque wings, the latter shining, transparent wings. A few Mayflies have no imaginal stage, and pair in the subimaginal stage.

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CHAPTER V

Order THYSANURA

(Bristle-tails, Silver-fish).

HIS Order contains those species which are generally considered to e the most primitive of living insects. Palaeontological evidence of ieir great antiquity will probably never be obtained, as, owing to the elicacy of their integument, they have left almost no fossil record xcept in Tertiary Amber. The recognition of their primitive condition rests entirely upon the absence of metamorphosis coupled with the close agreement of their structural details with those that are considered most primitive in the winged insects. Their generalized structure is well exemplified by the close resemblance of the Machilidae to certain Crustacea and of the Campodeidae to the Symphylous Myriapods, such as *Scolopendrella*.

Characters.—Wingless insects without metamorphosis and with few ecdyses; integument soft, clothed with hairs or scales; all segments of the body freely movable on one another.

H e a d with *compound eyes* and *ocelli* present or absent, *antennae* always with numerous segments, and often of considerable length. Mouth-parts extremely variable, but always of the mandibulate type; they may be well developed and normal in position, projecting beyond the head-capsule (Ectotrophica) or they may have the palpi much reduced and be entirely withdrawn inside the head-capsule (Entotrophica). *Mandibles* usually of the hard, toothed type, but in Machilidae of a more primitive form (fig. B1, b) closely resembling those of certain Crustacea, with incisor and molar areas widely separated. *Maxillae* with very variable palpi, the galea and lacinia of primitive form, both appearing as true gnathobases projecting inwards more or less at right-angles to the palp. *Labium* also of primitive form, with variable palps, divided ligula, separate glossae and paraglossae. *Hypopharynx* present, with a pair of side-lobes or paragnaths (fig. A7, A).

T h o r a x with the three segments well separated and more or less equally developed, the nota entire, the pleura little developed, the sterna entire or divided into sternum and sternellum. *Legs* well developed for walking and running, the femora and tibiae not much elongated, the tarsi with at most 3 segments, sometimes only one; claws small. *Spiracles* either two, three or rarely four pairs, the last case being that of the Japygidae, in which two pairs of spiracles occur on the metathorax.

A b d o m e n with ten complete segments, the tergites well developed, the sternites either entire or consisting of a central piece, usually small (sometimes absent), to which are attached posteriorly two

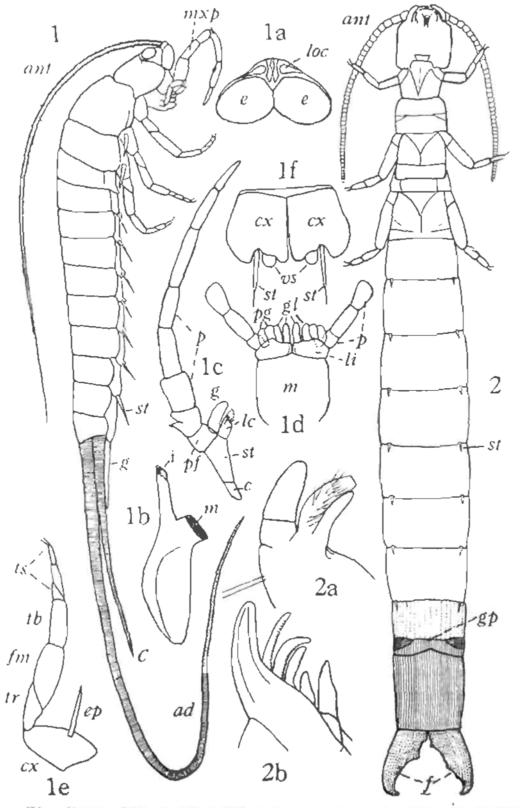


FIG. B1. *Nesomachilis maoricus* Till. n.sp., New Zealand. Fam. Machilidae. Length excluding caudal filaments 15 mm., *ad*, appendix dorsalis; *ant*, antenna; *c*, cercus; *g*, gonapophysis; *mxp*, maxillary palp; *st*, style; *1a*, head of same, enlarged, dorsal view; *e*, compound eye; *loc*, lateral ocellus; *1b*, mandible of same, showing the separate incisor (*i*) and molar (*m*) areas; *1c*, maxilla of same; *c*, cardo; *g*, galea; *lc*, lacinia; *p*, palp; *pf*, palpifer; *st*, stipes; *1d*, labium of same; *gl*, glossae; *li*, ligula; *m*, mentum; *p*, palp; *pg*, paraglossa; *1e*, middle leg of same; *cx*, coxa; *ep*, epipodite or style; *fm*, femur; *tb*, tibia; *tr*, trochanter; *ts*, tarsus; *1f*, fifth abdominal sternite of same; *cx*, coxite; *st*, style; *vs*, exsertile vesicle.

FIG. B2. *Heterojapyx gallardi* Till. n.sp., Australia. Fam. Japygidae; *ant*, antenna; *f*, forceps (cerci); *gp*, gonopore; *2a*, maxilla, external lobe with short palp; *2b*, maxilla, internal lobe.

large plates meeting in the middle line, and evidently representing the coxites or basal segments of original abdominal limbs. If, as is probable, the divided condition (Machilidae) is the more primitive, then the complete sternite is really a fusion of the true sternite with the coxites. In either case, some or all of sternites 1-9 are provided with paired simple appendages, termed *styles* (fig. B1, F, *st*), and sometimes also with one or two pairs of *exsertile vesicles* (*vs*), of unknown function, which can be protruded and expanded like small balloons. The styles are generally stated to be homologous with Crustacean epipodites, owing to their resemblance to the very similar appendages found on the coxae of middle and hind legs of Machilidae, which are true epipodites; there seems, however, to be no valid reason why they should not be the remains of true abdominal legs or endopodites, homologous with thoracic legs, since closely similar reduced conditions of endopodites occur frequently in the higher Crustacea. *Female* with a complete ovipositor in the Ectotrophica (absent in Entotrophica), formed from paired segmented gonapophyses on sternites 8-9 and the large gonocoxites of sternite 9, these latter carrying well-developed styles. Males with gonapophyses of sternite 9 present (except in Entotrophica), together with a penis, but, except in a few Machilidae, gonapophyses of sternite 8 absent. *Spiracles* 7 or 8 pairs (absent in Campodeidae). *Malpighian tubules* variable in number from 4 to 20; in Japygidae usually absent, but *Heterojapyx* has 6 vestigial ones.

Life History. Little is known of this. The *eggs* are oval or nearly spherical, deposited either singly in cracks or crannies of bark, rock, etc., or in masses in suitable holes in the ground. The young *larva* is very similar to the adult in form, and there are few instars, each being marked by a considerable increase in size.

Distribution. So little work has been done on the Thysanura of Australia and New Zealand that it appears probable that they are much better represented than at present appears. Of the five known families, only the rare Projapygidae are absent; they should, however, be discovered if carefully searched for. Each country possesses only a single Machilid, a single Campodeid and two or three Japygids; the Lepismatidae, though rare in New Zealand, are fairly numerous in Australia.

Fossil History. Numerous Machilidae and Lepismatidae are recorded from Baltic Amber (Oligocene) and a single Lepismatid from the Miocene of Florissant.

Economics. Introduced Silver-fish (Lepismatidae) do considerable damage in both countries to wall-paper and books, but the native species are harmless, being mostly bark-feeders. The other families are of no economic importance.

CLASSIFICATION.

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order THYSANURA 20 (5)

Suborder ECTOTROPHICA 16 (2)	1. MACHILIDAE 1 (1). 2. LEPISMATIDAE 15 (1).
Suborder ENTOTROPHICA 4 (3)	3. CAMPODEIDAE 1 (1). [PROJAPYGIDAE.] 4. JAPYGIDAE 3 (2).

The five families comprising the Order may, if desired, be considered as forming four very distinct superfamilies, Machiloidea, Lepismatoidea, Campodeoidea and Japygoidea; each of these would contain only a single family, except the Campodeoidea, which would include both Campodeidae and Projapygidae. The Order itself is divisible into two very distinct Suborders, considered by some authors as two distinct Orders:—

Mouth-parts normally placed, projecting externally to the head-capsule; maxillary and labial palpi of normal segmented form. Compound eyes nearly always present. A median, segmented appendix dorsalis present as well as two elongate, segmented cerci. Suborder ECTOTROPHICA

Mouth-parts withdrawn inside the head-capsule; maxillary and labial palpi short or absent. Eyes and appendix dorsalis absent; cerci present, but not always segmented.
Suborder ENTOTROPHICA

Suborder ECTOTROPHICA

The two families forming this Suborder may be distinguished as follows:—

Head with large compound eyes and three ocelli. Body subcylindrical, the thorax more or less convex dorsally. Slowly walking insects, with great powers of leaping. Fam. 1. MACHILIDAE

Head with small compound eyes (sometimes absent) and no ocelli. Body flattened dorso-ventrally. Very swift-running insects, incapable of leaping
Fam. 2. LEPISMATIDAE

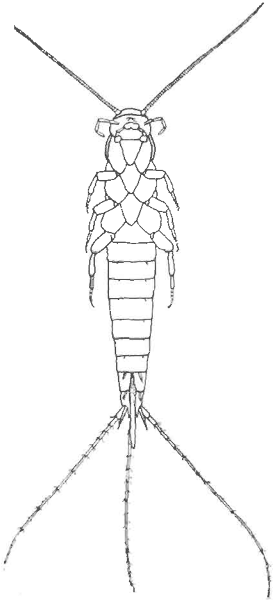
Family 1. **Machilidae** [Aus. 1, N.Z. 1]. Compound eyes large, often meeting mid-dorsally; ocelli large, often of peculiar form; antennae greatly elongated, filiform; mandibles (fig. B1, B) of primitive form, with widely separated incisor and molar areas; maxillary palpi with 7 segments; galeae and laciniae short, simple; labium broad, with 3-segmented palpi and broad ligula, the glossae and paraglossae each divided into two distinct lobes. Coxae of middle and hind legs with a style (epipodite), (fig. B1,F). Appendix dorsalis immensely elongated. Body completely clothed with scales.

This interesting family, which contains probably the most primitive of all living insects, and shows many close resemblances with the Crustacea, is represented only by two species of the primitive subfamily Meinertellinae, in which the abdominal sternites proper are either absent or very small, and there is never more than one pair of exsertile vesicles on a given segment. *Allomachilis froggatti* Silv. is of rare occurrence in Eastern Australia, usually near the sea-coast, while *Nesomachilis maoricus* Till., n.sp. (fig. B1) occurs in rocky or mossy situations in New Zealand, especially on Stephens Island.

Family 2. **Lepismatidae** (Bristle-tails, Silver-fish). [Aus. 15, N.Z. 1]. Compound eyes small or absent; ocelli absent; antennae elongate, filiform or moniliform; mandibles with hard teeth; maxillary palpi with 4-5 segments, the basal segment being very short or aborted; labial palpi with 3 segments. Appendix dorsalis and cerci more or less elongated. Body dorso-ventrally flattened, covered with scales.

Bark-haunting species of the subfamily Lepismatinae are not uncommon in Australia, the principal genera being *Heterolepisma* and *Acrotelsa*; most of the described species come from Western Australia. *Notolepisma zelandica* Till. (fig. B3) is found under the bark of native beech (*Nothofagus*) in New Zealand; it has minute styles on abdominal sternites 1-7 as well as larger styles in 8-9. The Nicoletiinae are represented by a number of smaller species, inquilines in ants' nests and termitaria in Australia, the best known being *Atelura cursitans* Frogg., remarkable for its speed in running.

The common introduced silver-fish in Australian houses is *Ctenolepisma longicaudata* Esch., originally described from South Africa. In New Zealand the common European silver-fish, *Lepisma saccharina* L., is abundant in houses. Both these species do a considerable amount of damage by gnawing paper, books, etc.



G. B3. *Notolepisma zelandica* Till. n.sp., New Zealand. Fam. Lepismatidae. Ventral view. Length, excluding appendages, 12 mm.

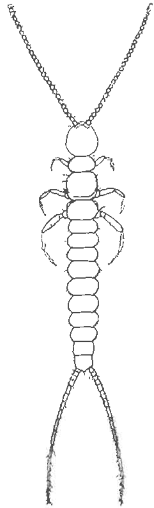


FIG. B4. *Campodea philpotti* Till. n.sp., New Zealand. Fam. Campodeidae. Dorsal view. Length, excluding appendages, 7 mm.

Suborder ENTOTROPHICA

Three families are known, one of which, the Projapygidae, has not yet been und in Australia or New Zealand, but is included in the Key, as follows:—

1. Cerci segmented, each segment carrying sensory hairs. 2
   Cerci unsegmented, forming a pair of hardened forceps. Fam. 4. JAPYGIDAE
2. Cerci long, with many segments. Fam. 3. CAMPODEIDAE
   Cerci short, with few segments. Fam. PROJAPYGIDAE

Family 3. **Campodeidae** [Aus. 1, N.Z 1]. Delicate, whitish or pale :llowish, *cylindrical insects of small size*; tracheal system reduced, with ree pairs of thoracic spiracles, but none in the abdomen. Mandibles strongly othed; maxillary and labial palpi absent; hypopharynx with side-lobes. Antennae id cerci elongated, many-segmented, with sensory hairs. Tarsi with a single gment. Abdominal sternites usually with styles and exsertile vesicles. *Campodea hilpotti* Till. (fig. B4) found in rotten wood on the Mt. Arthur Plateau, ew Zealand, is one of the largest known species, measuring 7 mm. in length xclusive of antennae and cerci; it is pale yellowish in colour. A much smaller, ndetermined species occurs not uncommonly amongst moss and débris in ustralia.

Family 4. **Japygidae** [Aus. 3, N.Z. 2]. Elongate insects living under stones and logs or burrowing in soil. Integument soft and whitish, except the last three segments and cerci, which are hard and dark in colour. Mandibles toothed; maxillae divided into two very diversely formed lobes, the external lobe representing the galea and shortened palp (fig. B2,B), the internal lobe the lacinia (fig. B2,A). Tarsi with a single segment. Abdomen broader than head and thorax, usually with styles on segs. 1-7; seg. 8 somewhat hardened; segs. 9-10 very hard, the former very short, the latter long. Cerci forming a pair of hardened forceps. Spiracles 11 pairs, four on thorax and seven on abdomen.

These insects superficially resemble Earwigs, but can be at once distinguished from them by the soft, creamy-white integument of all but the terminal segments, by the entotrophic mouth-parts, and by the abdominal segments being quite distinct, without any power of telescoping into one another; the internal anatomy is very distinct, the ovaries of the female being arranged segmentally and the Malpighian tubules aborted or vestigial. The genus *Heterojapyx* contains the largest of all known Apterygota, the females of the two Australian species measuring up to two inches in length, while those of the New Zealand species are somewhat less. *H. gallardi* Till. (fig. B2) is not uncommon in soil around Sydney, while *H. victoriae* Silv. occurs in Victoria. Much smaller species belonging to the genus *Japyx* are known from both countries. In captivity these insects burrow into the soil head first, and lie with only their forceps exposed; by this means they succeed in capturing other insects, woodlice, etc., which they drag down into the soil and devour at leisure.

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CHAPTER VI

Order PROTURA

In 1907 Silvestri described a minute insect discovered in soil in Italy as the sole representative of a new Order of wingless Insects, the Protura. The following year, Berlèse added two more genera. Though these insects have not yet been found in Australia or New Zealand, it seems very probable that they occur there, and would be found by careful searching. A short account of the Order is therefore given here, to enable students to recognize them if they find them.

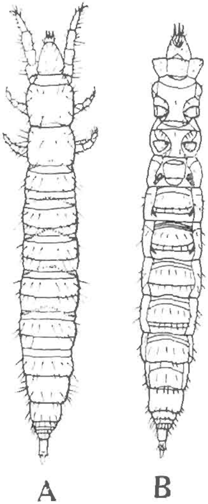

FIG. CI. *Acerentomum doderoi* Silv., Italy. Fam. Acerentomidae. Length 1.2 mm. A, dorsal view; B, ventral view. [After *Silvestri*.

Characters.—Minute, elongate, wingless insects, little more than 1 mm. in length, with soft integument.

Head small, pear-shaped; *compound eyes*, *ocelli* and *antennae* entirely absent. *Mouth-parts* withdrawn into the head-capsule, as in the Entotrophic Thysanura, but forming a sucking beak, of which the elongate *labrum* forms the upper part, the ligula of the *labium* the lower, while the styliform *mandibles* and shorter and slenderer laciniae of the *maxillae* work in between them; *maxillary* and *labial palpi* present, the former 4-segmented, the latter 3-segmented.

Thorax with rather short *prothorax*. *Legs* short, the forelegs longest; tarsi one-segmented, ending in a single claw.

Abdomen composed of *twelve* segments; segs. 1-8 large and subequal; segs. 9-11 much smaller, retractile telescopically into seg. 8; seg. 12 forming a small anal tube with supra-anal plate and paraprocts present. Segs. 1-3 with appendages or styles, those of seg. 1 largest. Female with short ovipositor. Male with a somewhat elongated genital forceps placed behind seg. 11.

The Order contains two families, Acerentomidae and Eosentomidae. There are but three known genera, *Acerentomum*, *Acerentulus* and *Eosentomon*. *Acerentomum doderoi* Silv. (fig. CI) was the first species to be described.

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CHAPTER VII

Order COLLEMBOLA

(Spring-tails).

THE insects comprised in this Order are mostly of small size, and agree with the Thysanura and Protura in being without wings at any stage, in possessing a soft cuticle, and in lacking any true metamorphosis. They are, however, very distinct in their general form, which is greatly shortened, and in the reduction in the number of segments of the abdomen to six and of the antennae to four (or, more rarely, six). Some recent authors have raised them to a separate Class, chiefly on the ground that they have only six abdominal segments, not only through their post-embryonic existence, but also in the embryo itself. This, however, is not justified, for Zoology furnishes numerous examples of high specializations in the embryonic stage; for example, certain star-fishes have the whole of the larval development cut out, and emerge from the egg as young star-fishes, while others, closely related to the former, still keep the whole of the usual embryonic and larval development. It will therefore suffice if we recognize the Collembola as a very distinct Order of Apterygota having no very near relatives.

Characters.—Soft-bodied, mostly very small insects, the cuticle smooth or granulated, sometimes clothed with hairs or scales.

Head:—*Compound eyes* either entirely absent or reduced to a set of separate ommata, eight or less in number (fig. D1, B); true *ocelli* absent; *antennae* usually with only four segments, rarely with six; a *post-antennal* organ of unknown function sometimes present. *Mouth-parts* retracted within the head-capsule as in the Entotrophic Thysanura; *mandibles* with separate molar and incisor areas; *paragnaths* present; *maxillae* and *labium* with palpi absent or only represented by a single seta.

Thorax with its segments fused into a close-fitting mass. *Pronotum* sometimes absent, sometimes well developed; in the former case, the *mesonotum* extends forward over the prothorax. *Legs* with only four distinct segments, viz., coxa, trochanter, femur and tibio-tarsus, the last ending in a single claw and an empodium somewhat like a smaller claw (fig. D1, C).

Abdomen with only six segments and no cerci. Seg. 1 carries a ventral process called the *ventral tube* or *collophore* fig. D1, A, *vt*); this process is simple or bifid, and carries at its free end a pair of eversible sacs which exude a sticky substance, enabling the insect to adhere to smooth surfaces. Seg. 4 or 5 carries a much longer ventral appendage, formed by the partial fusion, basally, of two original ap-

pendages, and known as the *spring* (fig. D1, A, D); this spring is held in a forwardly projecting position below the abdomen, and can be released with considerable force, causing the insect to skip vigorously. The spring itself consists of a basal fused portion, the *manubrium* (fig. D1, A, *mn*), followed by two elongated pieces called the *dentes* (fig. D1, D, *dn*), each ending in a tiny, claw-like *mucro* (*mu*). An additional small appendage is sometimes present on seg. 3; it is bifid distally and

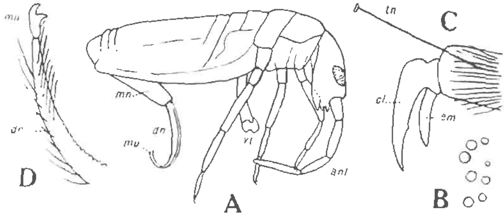

FIG. D1. A, *Entomobrya mawsoni* Till., Macquarie Island. Fam. Entomobryidae, lateral view, length 2.5 mm.; *ant*, antenna; *dn*, dens of spring; *mn*, manubrium of spring; *mu*, mucro of spring; *vt*, ventral tube; B, group of separate ommata from dark patch on either side of head, greatly enlarged; C, end of hind tarsus, enlarged, showing claw (*cl*), empodium (*em*), and tenent hair (*tn*); D, end of dens (*dn*); and mucro (*mu*) of spring, greatly enlarged. [*R. J. T. del.*

is supposed to be of use for holding the spring in position; hence it has been termed the *catch* or *tenaculum*. *Spiracles* are either entirely absent, or only present in the head region. *Malpighian tubules* present.

Life History.—Little is known of the life history of this Order. Both adults and the not dissimilar larval forms (in which, usually, the segments are not so completely fused together) are found on the ground, in débris; moss or leaves, sometimes under rocks or logs, sometimes living on the surface of water; they feed on vegetable matter. The number of instars is not known for certain, but is probably small in most cases.

Distribution.—Little is known of the Collembola of Australia and New Zealand. Entomobryidae are abundant everywhere, especially in the autumn and winter months. Poduridae also are abundant in places, but very few have been described, while the Symphypleona, which are evidently rare throughout, are represented only by very few species in both countries.

Fossil History.—These small and delicate insects have left absolutely no fossil record except in Baltic Amber (Oligocene) from which a number of species have been described. The families represented are Poduridae and Sminthuridae.

Economics.—Most of the species are harmless, but Sminthuridae sometimes increase to such an extent as to do considerable damage to crops. An undetermined species of this family did great damage to the lucerne crop in South Australia in 1896.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES*

Order COLLEMBOLA 42 (15)

Suborder ARTHROPLEONA 37 (13)	1. PODURIDAE 6 (7) 2. ENTOMOBRYIDAE 31 (6)
Suborder SYMPHYLEONA 5 (2)	3. SMINTHURIDAE 5 (2) [NEELIDAE]

There are two Suborders, distinguished as follows:—

Body elongated, the abdomen subcylindrical, mostly with the segments entirely free, but sometimes with partial fusion of the tergites. Tracheal system almost always absent. *Suborder ARTHROPLEONA*

Body short, the abdomen globular, with the segments wholly or partially fused together. Tracheal system present. Suborder SYMPHYPLEONA

Suborder ARTHROPLEONA

This Suborder contains only two families, easily recognized as follows:—

Prothorax well developed, the pronotum present. Cuticle usually granulated. Spring either absent, or attached to fourth sternite of abdomen. Fam. 1. PODURIDAE

Prothorax poorly developed, with no pronotum; the mesonotum completely covering it. Cuticle smooth. Spring present, attached to fifth abdominal sternite. Fam. 2. ENTOMOBRYIDAE

Family 1. **Poduridae** [Aus. 6, N.Z. 7]. This family includes only

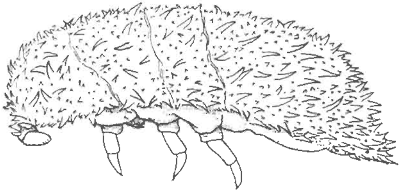

FIG. D2. *Holacanthella spinosa* Lubb., New Zealand. Fam. Poduridae. Lateral view. Length 10 mm. [*A. Tonnoir del.*

moderately elongated species, having the antennae always with only four segments, generally short and poorly developed; the tibio-tarsus has a single claw with or without an empodium; the spring, when present, is not very elongated. A post-antennal organ is frequently present, generally rosette-shaped. The subfamily Achonitinae contains prognathous species without ommata; they are mostly minute insects, some living in moss, moist earth, etc., others on the *surface of still water. Triacanthella alba Carp. is an interesting little species from* Auckland Island, while the almost world-wide *Achorutes viaticus* Tull. is common on Macquarie Island. In the subfamily Neanurinae are included prognathous species with ommata; some of them are inert insects having no spring, found in moss, rotten wood, etc., or under logs and stones. *Pseudachorutes* is

*The species from Macquarie and Campbell islands are included in the New Zealand census.

found in both countries: *Acanthanura* is confined to Tasmania, *Platanurida* to New Zealand. The giant of the Order is the huge *Holacanthella spinosa* Lubb. (fig. D2) from New Zealand, of a dull slaty colour, reaching up to 10 mm. in length.

Family 2. **Entomobryidae** [Aus. 31, N.Z. 6]. This is the dominant family of the Order, and is quite well represented both in Australia and New Zealand. The antennae have from four to six segments. The subfamily Isotominae contains scaleless species with the post-antennal organ present and the third and fourth abdominal segments equal: they occur in moss, dead leaves, etc. *Cryptopygus niger* Carp. is a New Zealand species belonging to an American Antarctic genus. In the subfamily Tomocerinae are placed those species having scales on the body, no post-antennal organ, and the fourth abdominal segment much shorter than the third. Two species of *Lepidophorella* are known from New Zealand, one of which, *L. brachycephala* Moniez, was originally placed in the genus *Drepanura*. In the Entomobryinae, the fourth abdominal segment is much longer than the third. *Entomobrya* is a world-wide genus, of which a fine representative, *E. mawsoni* Till. (fig. D1) occurs on Macquarie Island under stones in penguin rookeries; nine species of this genus are known from Queensland, and an equal number also of the scaly genus *Lepidocyrtoides*. Other genera known from Queensland are *Sinella*, *Pericrypta*, *Coelura*, *Sira*, *Lepidocyrtus* and *Cyphoderus*, while *Paronella* has representatives both in Queensland and New Zealand. One peculiar genus, *Axelsonia*, lives in barnacles, and may well occur in Australia.

Suborder SYMPHYPLEONA

Of the two known families in this Suborder, one, the Neelidae, is only represented by two rare genera, *Neelus* and *Megalothorax*, not found in Australia or New Zealand, and distinguished from the Sminthuridae by having the thorax longer than the abdomen.

Family 3. **Sminthuridae** (Globular Spring-tails) [Aus. 5, N.Z. 2]. The insects of this family are small, globular spring-tails, whose great powers of leaping, in comparison with their size, are truly remarkable. Three species of *Sminthurinus* and one of *Katianna* are recorded from Queensland. *Arrhopalites dawsi* Till., from Macquarie Island, is a minute, purplish-black insect found in moss and crevices of rock: the last segment of the antenna is long and annulated, and the two mucrones of the spring are long, slender and similar in shape: both these characters are generic.

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CHAPTER VIII

Order PLECTOPTERA

(or EPHEMEROPTERA)

(May-flies)

THE May-flies are delicately formed, aërial insects, which can be at once recognized by their short, filiform antennae, aborted mouth-parts, greatly reduced hindwings and long caudal filaments, usually three in number; they are only found in the neighbourhood of water, and are mostly crepuscular in their habits, dancing or drifting in the air, sometimes in large swarms. They are unique in possessing two winged stages, the subimago and imago; the former has opaque wings, and flies but little; the latter has transparent wings, and is active in flight.

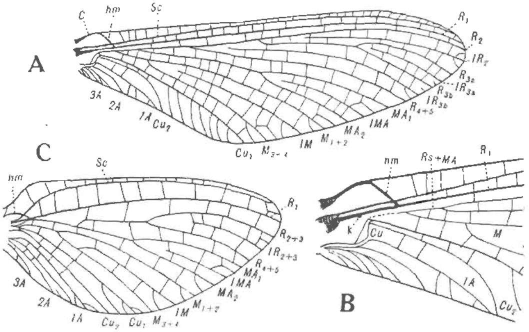

FIG. 61. *Ameletus ornatus* Eat., New Zealand. Fam. *Siphlonuridae*. A, fore-wing, length 17 mm; B, base of same, enlarged to show humeral brace-vein (*hm*) and stump of original base of *Rs* (*k*); C, hind-wing of same, length 6 mm. Lettering as in fig. A8, p. 22, and table on p. 59; note the triadic arrangement of the veins and the numerous branches of *Rs*. [*R. J. T. del.*

Characters. Head short, transverse; *compound eyes* always present, much larger in male than in female; sometimes each eye in the male is divided into two parts, the upper being the larger; this upper part may be raised upon a projecting cylindrical base, and is then called a *turban-eye*; three *ocelli* always present; *antennae* short, subulicorn, with two distinct basal segments and an indistinctly segmented flagellum. *Mouth-parts* aborted.

Thorax with *prothorax* of variable size, *mesothorax* always the largest, much larger than *metathorax*. *Legs* weak and short, except forelegs of male, which are elongated and held out in front of the head almost like a pair of antennae; *tarsi* with a variable number of segments, from five to one; tarsal claws often modified.

Wings attached to thorax by a single axillary only, and held vertically above the body, pressed close together, back to back. Hindwing always much smaller than forewing, never (in recent forms) more than one-third of it in size, sometimes entirely absent. *Venation* of a very primitive type, with the branches all arranged in complete triads (fig. E1), except sometimes on Cu_1, where a pectinate series may be developed. In recent May-flies, the middle member of each triad generally has its base detached from the other two members of the triad, so that it appears to be an interpolated vein of later origin. The Lower Permian May-flies, however, have exactly the same triads as in recent May-flies, but the middle member of each triad is normally attached to one or other of the outer veins enclosing it. The venation of this Order agrees with that of the Palaeozoic Palaeodictyoptera and related Orders in the possession of a complete archaic media, composed of an anterior, convex branch, *MA*, and a posterior, concave branch, *M*; as both of these carry a simple triad, we use the notation MA_1, MA_2 for the convex branches of the former, with *IMA* as the interpolated concave vein, and the notation M_{1+2}, M_{3+4} for the concave branches of *M* (these being strictly homologous with the veins so denoted by Comstock in most other Orders), with *IM* for the interpolated convex vein. *Forewing* with *Rs* detached from its original base (represented by the stump *k* in fig. E1) and connected with *MA*; an oblique humeral brace-vein present (fig. E1, *hm*), preceded by a short basal thickening of the costa; this latter formation is the remains of an original, separate, short, costal vein, with descending distal branch, present in the Permian fossils. Owing to the complete system of triads, convex and concave veins alternate with one another regularly along the margin of the wing, which is thus thrown into marked folds formed by the alternating grooves and ridges. *Sc* simple, running nearly to apex; R_1 also simple, running to apex or nearly so; *Rs* with three primary, concave branches, viz., R_2, R_3 and R_{4+5}, but R_3 itself with a terminal triad, viz., R_{3a}, IR_{3a} and R_{3b}; two convex veins interpolated between the original three branches, viz., IR_2 and IR_{3b}, making seven branches in all; sometimes a definite chitinized spot, or bulla (fig. E6, *b*) is present on R_{2a} about half-way; *M* and *Cu* always more or less bent upwards at base; Cu_1 often connecting with *M* near its bend by a very short M_5; *MA* and *M* simple triads; Cu_1 with a number of descending branches either arranged as modified triads or in a single pectinate series; Cu_2 a simple concave vein bounding the small convex anal area, on which three short anal veins, all convex, branched or simple, are developed. *Hindwing* often with costa much arched near base, sometimes strongly angulated, the wing-coupling being of the amplexiform type, similar to that found in Butterflies (p. 402). *Rs*, *MA* and *M* either simple triads or single veins. Cross-veins usually abundant, irregular, always at right-angles to main veins, sometimes much reduced in number, or absent.

Until recently, the venation of May-flies has not been correctly understood, and several diverse systems of notation were in vogue. Eaton, whose fine work on the Order is acknowledged by everyone,

had his own system, antedating that of Comstock and Needham, which need not be considered here. Comstock and Needham provided a new notation, originally with the branches of *Rs* and *M* arranged in logical sequence. There followed an exhaustive study of the larval wings by Miss Morgan, who, in a thesis evidently inspired by the idea that *Rs* would be found crossing *M* as in Odonata, actually set forth that extraordinary interpretation, although she only succeeded in finding one such tracheal crossing (in *Heptagenia*) in the numerous larval wings examined. As the theory of a crossing of *Rs* in Odonata is no longer tenable, her system falls with it. The new system here given has been derived from a combined study of the Lower Permian fossils and the larval wings of archaic New Zealand Siphlonuridae, both methods of study giving similar results. The New Notation here given differs from that originally proposed by me (1922) in that it takes into account the presence of Lameere's anterior median *MA*, which I originally considered to be R_{4+5}. The following Table exhibits the three systems:—

New Notation	Convex (+) or concave (−)	Comstock-Needham Notation	Morgan's Notation
C	+	C	C
Sc	−	Sc	Sc
R_1	+	R_1	R_1
R_2	−	R_2	M_1
IR_2	+	(omitted)	(omitted)
R_{3a}	−	(omitted)	(omitted)
IR_{3a}	+	(omitted)	(omitted)
R_{3b}	−	R_3	Rs
IR_{3b}	+	R_4	Interpolated vein I
R_{4+5}	−	R_5	M_2
MA_1	+	M_1	M_3
IMA	−	M_2	(omitted)
MA_2	+	M_3	M_4
M_{1+2}	−	Cu_1	Cu_1
IM	+	Interpolated vein	Interpolated vein
M_{3+4}	−	Cu_2	Cu_2
Cu_1	+	*1A*	*1A*
Cu_2	−	*2A*	*2A*
1A	+	*3A*	*3A*
2A	+	*3A*	*3A*
3A	+	*3A*	*3A*

Abdomen slender, usually cylindrical, with ten complete segments; tenth segment ending in an *appendix dorsalis* and two *cerci* forming three usually similar, elongated *caudal filaments*, each with numerous segments; sometimes the appendix dorsalis is reduced or absent. *Spiracles* eight pairs, on segs. 1-8. Alimentary canal receiving no food, but inflated with air in imago. Male (fig. A11) with ninth sternite bearing well developed gonocoxites and long, segmented styles; aedeagus consisting of a double symmetrical penis with or without parameres; tenth sternite complete. Female without an ovipositor, but having a wide vulva, *opening between the seventh and eighth sternites*, the two oviducts opening separately into it; seventh sternite often developed as a strong *subgenital plate*; eighth sternite short; ninth sternite sometimes prolonged as a *ventral plate*. *Malpighian tubules* numerous in larvae.

Life History. The early stages are passed entirely in the water, he *eggs* being protruded in two large masses, and washed out of he body of the female, falling freely on the bed of the stream. The larvae (figs. E2, 3, 4) are either vegetarian or carnivorous, and nostly roam freely on the stream-bed (fig. E2) or hide under rocks fig. E3); some, however, burrow into the banks (fig. E4), and thus void becoming a prey to fishes until they emerge; they are elongate,

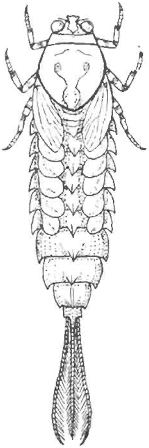

FIG. E2. Free-swimming larva of *Oniscigaster distans* McL., New Zealand. Fam. Siphlonuridae. Length of of body 24 mm. [*R. J. T. del.*

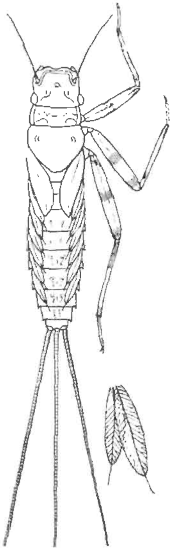

FIG. E3. Rock-dwelling larva of *Atalophlebia costalis* Burm., Australia. Fam. Leptophlebiidae. Length of body 12 mm. At side, one pair of gills from fifth *abdominal segment*, enlarged. (The long tail-filaments are only partially figured.) [*R. J. T. del.*

FIG. E4. Burrowing larva of *Ichthybotus hudsoni* Eat., New Zealand. Fam. Ephemeridae. Length of body 27 mm. [*R. J. T. del.*

with strong legs, three caudal filaments, and a more or less complete system of paired segmental gills on the abdomen. In most cases hese gills are double, more or less leaf-like, with numerous tracheal ranches ramifying in them; they are generally thrown over the back of the larva, the abdomen being pressed flatly down against the surface on which it rests. The number of larval instars is large, twelve or more, wing-buds appearing when the larva is less than half-grown.

and increasing in size through the last five or six instars. The newly-hatched larva has no gills; they arise as slender filaments, a pair or two at a time, from the second instar onwards. When full-grown, the larva swims or climbs to the surface of the water, and there discloses the winged *subimago*, which flies straight up from the water to find a refuge in some near-by foliage or on a rock. This stage lasts three or four days in the older forms, only a few minutes in the highest types; from it there emerges the true *imago*, with transparent wings and mature reproductive organs. This also lives only a few days, and takes no food, the mouth-parts being aborted. Pairing takes place in the air, during the evening flights or dances, and is of short duration, the female at once descending to the water to wash off the eggs, which extrude in a sticky, yellowish mass from the abdomen.

Distribution. Only four families of May-flies are represented in Australia, and one of these, the Baëtidae, is not found in New Zealand. In the other three families, the Australian and New Zealand genera are either the same or very closely allied, and all appear to have had a common origin, probably from Antarctica. The New Zealand species are larger, more brightly-coloured, and much more abundant in individuals than the Australian, as might be expected, owing to the much greater number of fast running rivers, in which these insects live. But the introduced trout have greatly diminished this once abundant fauna, and some species are extinct, or nearly so.

Economics. This Order is entirely beneficial, both the larvae and adults forming one of the best foods for freshwater fishes. Indeed, the art of Fly-fishing is based chiefly upon the keen desire of the trout for the winged May-fly. Unfortunately the May-fly fauna of Australia and New Zealand is not specialized to hold its own against the introduced Brown and Rainbow Trout, and is rapidly being reduced to a minimum, none of the larvae except those of *Ichthybotus* being burrowers.

Fossil History. No fossil May-flies have so far been found in Australia, and it is probable that the Order was never really abundant there, and only became established fairly late in Mesozoic times. True May-flies occur in the Lower Permian of Kansas, but differ from those of the present day in having both fore and hindwings large and almost equal. Some of these forms were even larger than the New Zealand Siphlonuridae existing to-day. Jurassic May-flies are also known, having the hindwings reduced, but considerably larger than at the present day.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order PLECTOPTERA 20 (20)

1. SIPHLONURIDAE 4 (7)	3. LEPTOPHLEBIIDAE 12 (11)
2. EPHEMERIDAE 1 (2)	4. BAETIDAE 3 (0)

The four families represented in our faunas are only a small fraction of the numerous diverse types of May-flies occurring throughout the world; they stand so far apart from each other that each

may be taken as belonging to a separate superfamily, if so desired. They may be distinguished by the following Key:—

1. Hindwings well developed, from one-half to one-third as long as forewings 2
   Hindwings very small or absent, at most less than one fourth as long as forewings 3
2. Prothorax well developed, usually about as long as wide; forewing with *Cu* bent at an acute angle near where it forks basally, and attached to *M*; Cu_1 sigmoidally curved. Fam. 2. EPHEMERIDAE
   Prothorax much shorter than wide; forewing with *Cu* bent at right-angles where it forks basally, not attached to *M*; Cu_1 an almost straight vein ending up about half-way along the wing, just beyond tornus. Fam. 1. SIPHLONURIDAE
3. Forewing with numerous cross-veins; hindwing from about one-fifth to one-seventh of forewing in length; male without turban eyes. Fam. 3. LEPTOPHLEBIIDAE
   Forewing with very few cross-veins; hindwing minute or absent; male with turban eyes and very iridescent wings. Fam. 4. BAETIDAE

Family 1. **Siphlonuridae** [Aus. 4, N.Z. 7]. *Forewing with tornus well* developed at from two-fifths to nearly one-half the wing-length from base, the nearly straight Cu_1 ending up just beyond it, and having a descending series of pectinate branches; Cu_2 curved concavely to Cu_1. Larvae either active, free-swimming and carnivorous, or torpid, clinging to rocks in fast running streams.

This fine and undoubtedly very archaic family is well represented in New Zealand by the genera *Ameletus*, *Oniscigaster* and *Coloburiscus*; the first two genera have free-swimming, somewhat shrimp-like larvae with double lamellate gills, the last-named a highly specialized larval type with swollen thorax and peculiar bifid gills which give it a protective resemblance to a piece of aquatic vegetable *growth on the rock to which it clings. Ameletus ornatus* Eat. (fig. E1 and pl. 10, fig. 1) expands from one to one and a half inches, the subimago having the wings variably mottled in brownish or olive-green, the imago with hyaline wings. The shrimp-like larva often rests exposed on damp rocks close to the spray of cascades and waterfalls; when threatened with danger, it *jumps vigorously back into the water, the action being very suggestive of* that of a Machilid, which it superficially resembles. *A. perscitus* Eat. (pl. 2, fig. 1) is a much larger species of more robust build, lemon-yellow in both winged instars; its larva has a very large head, and is highly carnivorous. Larvae of the *Ameletus* type, but with fewer gills, occur in small streams on the Blue Mountains, New South Wales, but *the imagines are not yet known. Coloburiscus humeralis* Walk. is much the commonest of the large New Zealand May-flies; it can be recognized by the shaded costa of forewings, the sharply angulated costa of the hindwings, and the aborted appendix dorsalis: the imago is not unlike that of *A. ornatus* Eat., but the subimago has dull, greyish, *unornamented wings. This genus is also represented by two fine* species in Australia, *C. haleuticus* Eat. in Victoria and a very large, undescribed species on Mt. Kosciusko. *Oniscigaster wakefieldi* McL., now almost extinct, is remarkable for its broad abdomen with lateral dilatations of abdominal segs. 7-9. *O. distans* Eat. (pl. 10, fig. 2) is a larger species, the females expanding up to *2 inches, without lateral dilatations. The beautiful subimago, with* purplish-black wings, has been kept alive for three days before disclosing the very different, hyaline-winged imago. The larva (fig. E2) is dorso-ventrally flattened, living freely on the fine, gravelly beds of small mountain streams; it cannot dart forward like the larvae of *Ameletus*, and has little chance of survival against *the introduced trout. Tasmanophlebia lacustris* Till. *(pl. 10, fig. 3)* is a small, lake-dwelling species allied to *Oniscigaster*, found in Tasmania.

Family 2. **Ephemeridae** [Aus. 1, N.Z. 2]. Prothorax well developed, as long as wide. Forewing with well developed tornus at one-third to two-fifths of wing-length from base, with Cu_1 ending beyond it; Cu_1 acute-angled at its basal fork *and fused for a short space with M.* Larvae *(fig. E4)* burrowers, with short, feathery gills kept continually in motion so as to ensure a flow of water through the burrows. The New Zealand species are the fine *Ichthybotus hudsoni* McL., expanding 1½ to over 2 inches, in the North Island, and *I. bicolor* Till., a smaller and rarer species with dark hindwings in imago, found in the South Island. *Both sexes agree in having the costa strongly shaded with reddish-*brown, but the females in both species have yellowish wings, those of the male

being hyaline; the subimagines have in addition dark blotches or complete fasciae on the wings. Larvae resembling those of *Ichthybotus* occur also in the Fish River in New South Wales, but the imago is not known.

The Great Papuan May-fly, Plethogenesia papuana Eat., *belongs to this family;* though its rich, creamy-yellow subimago has been seen in countless numbers on the Fly River, not a single imago has ever been observed, and it is believed that this species mates and dies in the subimaginal stage.

Family 3. **Leptophlebiidae** [Aus. 12, N.Z. 11]. Forewing with tornus more or less well marked, always close to base (at one-fourth of wing-length from base or less) in correlation with the greatly reduced hindwings. Cu_1 attached to M at a point just beyond its origin and very strongly angulated *there; branches of* Cu_1 *few;* Cu_2 *sigmoidally curved, ending not far short of* tornus; anal veins much reduced. A bulla (fig E6, *b*) usually present on R_{2a} about half-way along the wing. Larvae (fig. E3) active, carnivorous, hiding under rocks or stones in still or running waters: gills lanceolate.

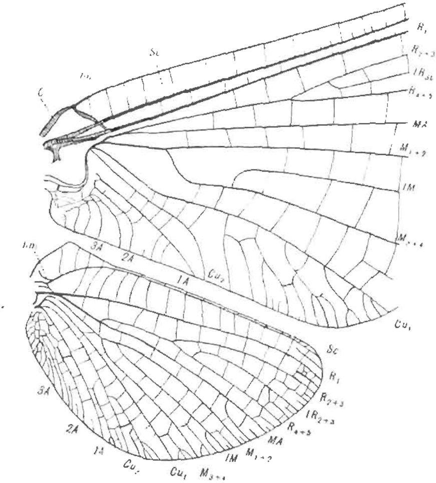

FIG. E5. *Ichthybotus hudsoni* McL., New Zealand. Fam. Ephemeridae. Hindwing and basal portion of forewing. Length of hindwing 6.5 mm. Lettering as in fig. E1, p. 57. Note *IM* of forewing switched on to M_{3+4}. [*R. J. T. del.*

This is the dominant family of May-flies in both countries, the principal genus being *Atalophlebia* with numerous species. *A. costalis* Burm. (pl. 10, fig. 5), the commonest May-fly in Australia, is a rich brown species remarkable for the enormous length of the cerci in the males; the appendix dorsalis is usually aborted. The larva (fig. E3) is handsomely variegated in fuscous and olive-green. Of several fine New Zealand species, the reddish-brown *A. dentata* Eat. (pl. 2, fig. 2) and *A. cruentata* Huds. are barely distinguishable in the winged stages, though the larvae are distinct both in colour and shape. *A. versicolor* Eat. (pl. 10, fig. 4) has a subimago with richly variegated wings. Of a number of very small species, the New Zealand *Deleatidium lillii*

Eat. occurs in great swarms in many localities: this genus, *Thraulus* and *Euphyurus* are all represented in Australia.

Family 4. **Baetidae** [Aus. 3, N.Z. 0]. This family is only represented in Australia by three species of tropical origin: they are of very small size.

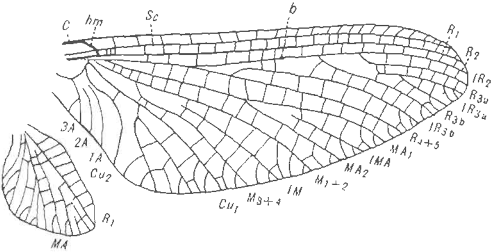

FIG. E6. *Atalophlebia costalis* Burm. (pl. 10, fig. 5), Australia. Fam. Leptophlebiidae. Wing-venation. Length of forewing 10 mm. Lettering as in fig. E1, p. 57, except *b*, bulla. [*R. J. T. del.*

with few cross-veins, the hindwings minute or absent, the males with turban eyes. The larvae inhabit slow or stagnant waters. *Baëtis soror* Ulm. reaches as far south as Sydney. The male of *Chloeon viridis* Klap. has the forewings a brilliantly iridescent green; the hindwings are absent.

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CHAPTER IX

Order ODONATA

(or PARANEUROPTERA)

(Dragonflies, Damsel-flies)

THIS Order, sometimes called Paraneuroptera, comprises about 2,500 species throughout the world, but is most abundantly represented in the Tropics. Dragonflies are familiar to everybody on account of their beauty of form and colouring and their remarkable skill in flying. They can be recognized at once by their large eyes, their obliquely placed

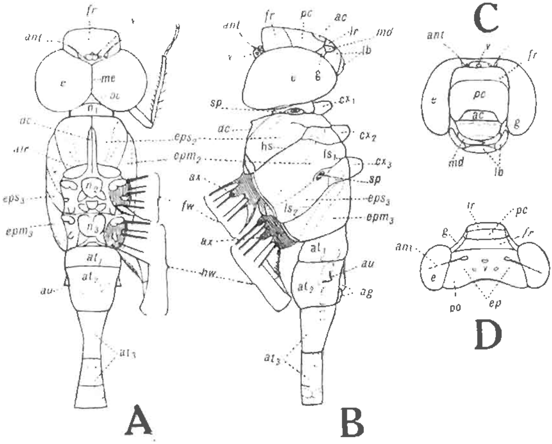


FIG. F1. Head, thorax and first three abdominal segments of *Aeschna brevistyla* Ramb., Australia and N.Z., fam. Aeschnidae. A. dorsal view; B, lateral view; C, front view of head (all × 2); D, head of *Austrolestes leda* Sel., Australia, fam. Lestidae, dorsal view (× 5.3); *ac*, anteclypeus; *ag*, accessory genitalia; *alr*, ante-alar ridge; *ant*, antenna; at_1-at_3, first three abdominal tergites; *au*, auricle; *ax*, axillary; *cx*, coxa; *dc*, dorsal carina; *e*, eye; *ep*, epicranium; *epm*, epimeron; *eps*, episternum; *fr*, frons; *fw*, forewing; *g*, gena; *hs*, humeral suture; *hw*, hindwing; *lb*, labium; *lr*, labrum; ls_1, ls_2, first and second lateral sutures; *md*, mandible; *me*, median eye-line; *n*, notum; *oc*, occiput; *pc*, postclypeus; *po*, postocular lobe; *sp*, spiracle; *v*, vertex. [*R. J. T. del.*

thorax, with the legs placed far forward and the wings well backward, and by their very elongated abdomen. They have no very close relatives amongst existing insects, but share with the May-flies the distinction of being the only insects whose wings are attached to the thorax by means of a single axillary and are moved directly by the great thoracic muscles. They are, on the whole, much more highly specialized than the Mayflies, both in their larval and adult stages.

Characters. Medium to very large insects with an expanse of wing from three-quarters of an inch to seven inches; aërial in habit, predaceous on other insects, which are captured on the wing.

Head (fig. F2) either broader than long, dumb-bell shaped, with button-shaped *compound eyes* (*c*) placed laterally, or more or less globular, with the eyes occupying most of its area and often meeting in the middle line; *ocelli* three, always present; *antennae* short, subulicorn, with 4-7 segments. *Mouth-parts* strongly mandibulate; *man-*

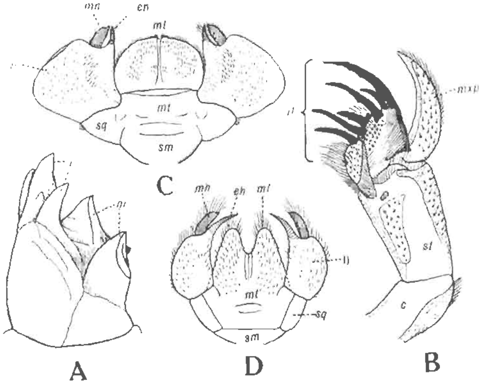


FIG. F2. *Aeschna brevistyla* Ramb. A, mandible; B, maxilla; C, labium; D, labium of *Synlestes weyersi* Sel., Australia, fam. Synlestidae, with cleft median lobe; *c*, cardo; *eh*, end-hook; *i*, incisors; *il*, inner lobe of maxilla; *ll*, lateral lobe of labium (= first segment of labial palp); *m*, molar; *mh*, movable hook (= second segment of labial palp); *ml*, median lobe (= ligula); *mt*, mentum; *mxp*, maxillary palp; *sm*, submentum; *sq*, squame (= palpiger); *st*, stipes. [*R. J. T. del.*

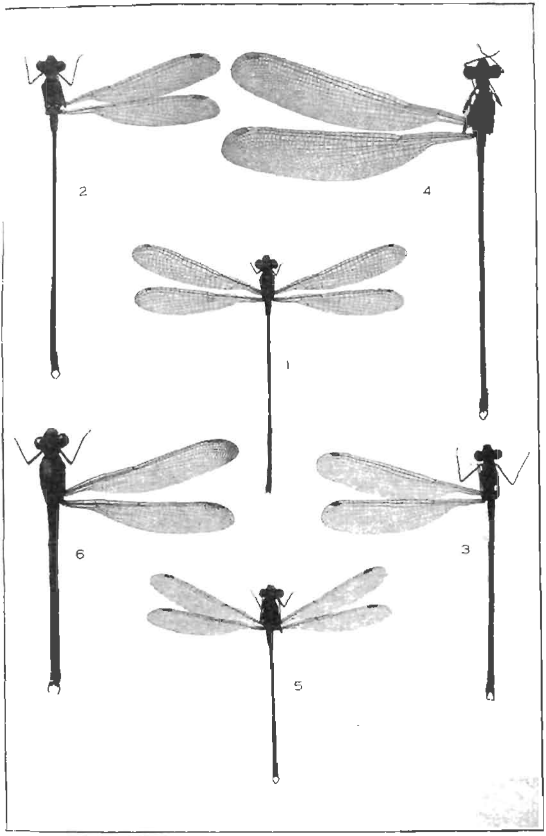
dibles (fig. F2, A) hard and furnished with strong incisor and molar teeth; *maxillae* (fig. F2, B) with an unsegmented palp and strongly-toothed internal lobe; *labium* (fig. F2, C, D), short and broad, with short, broad submentum and mentum, the latter with two side-pieces known as squames (*sq*), which are clearly the palpigers; ligula, known as the median lobe, cleft in the more archaic types (fig. F2, D), entire in the higher types (fig. F2, C); palpi with two segments only, the basal one in the form of a broad piece known as the lateral lobe (*ll*), the second much smaller, forming

PLATE 3

AUSTRALIAN ODONATA (ZYGOPTERA)

All figures natural size

1. *Pseudagrion ignifer* Till. (Fam. COENAGRIIDAE), male.
2. *Synlestes weyersi* Sel. (Fam. SYNLESTIDAE), male.
3. *Argiolestes icteromelas* Sel. (Fam. MEGAPODAGRIIDAE), male.
4. *Podopteryx roseonotata* Sel. (Fam. MEGAPODAGRIIDAE), male.
5. *Austrolestes cingulatus* Burm. (Fam. LESTIDAE), male.
6. *Diphlebia lestoides* Sel. (Fam. AMPHIPTERYGIDAE), male.



W. C. Davies photo.

AUSTRALIAN ODONATA (ZYGOPTERA)

a movable hook (*mh*). Head attached to thorax by a very small neck region, giving it great mobility in all directions.

Thorax (fig. F1) composed of a small *prothorax*, separated off from a large, obliquely placed *pterothorax*, composed of the closely fused *meso-* and *metathorax*. The dorsal portion of this latter region is not, as might be expected, the notal region, but is formed of an overgrowth of the pleural regions, which meet together along a considerable distance in front of the true notal region. This latter is consequently forced backwards and becomes more or less vertical in position, carrying the wings with it. In the same way, an undergrowth and fusion of the pleural regions ventrally forces the true sterna forward, carrying with them the legs, all three pairs of which thus come to lie close up to the mouth. *Legs* short, not fitted for walking, their only uses being for climbing stems, clinging to branches, or for seizing and holding the prey; coxae short, fairly stout; trochanters slender, divided into two portions by a marked constriction near the base; femora strong, often armed with spines; tibiae slender, elongated, without spurs, but often armed with spines and sometimes with a ventral keel; tarsi with three segments, the distal one being the longest, and ending in a pair of claws, each of which usually carries a sharp tooth; between the claws is a tiny pad called the *plantula*, a vestige of the empodium. *Spiracles* two pairs.

Wings attached to the thorax by a single axillary only (fig. F1, B, *ax*) and worked directly by the great thoracic muscles; in the position of rest, they are either folded vertically back above the abdomen, or held out horizontally at right-angles to the body, but are incapable of being laid either flatly or roof-wise upon the abdomen. *Membrane* stiff, with strong veins, entirely hairless.

Venation very highly specialized, the homologies of the veins being difficult to interpret. Originally, de Selys gave a distinct nomenclature to the veins, known as the Selysian system, without notation. Later on, Needham gave an interpretation based on the larval wing-tracheation, with a notation based on the Comstock-Needham system. This notation has been in almost universal use for the past twenty years or more. Recent investigations of the larval wing-tracheation have thrown serious doubts upon Needham's interpretation of the veins below R_1, especially his *Rs* (IR_3 of the New Notation). The discovery of new fossil forms of Odonata in the Upper Trias and Lower Permian has confirmed these doubts, so that Odonatologists are now in the position of having to reject a system to which they had become thoroughly used, and to substitute for it a new system based on the newly acquired facts. Though no such system is at present in use, the recent work of Lameere, based upon a critical study of the extinct Orders Palaeodictyoptera and Protodonata, is a valuable step in the right direction. There can be little doubt, from the fossil evidence, that Lameere is correct in stating that Needham's vein Cu_1 (concave) is the homologue of Cu_2 in other Orders of Insects, and that Needham's Cu_2 (convex) is the homologue of *1A*. Lameere's interpretation of the limits of *Rs* and *M* is not so obvious; but we may, I think, accept the determination of Needham's vein *M* (convex) provisionally as the anterior portion of the original media of the fossil Palaeodictyoptera, using the notation *MA*, and bearing in mind Lameere's statement that he considers that both the lower concave half of the original media and the upper convex portion of *Cu* (i.e., Cu_1

of other Orders) have been lost in the Odonata. As a matter of fact, both convex and concave portions of M, and also the true Cu_1, are present in the Protagriidae (Order Protodonata), which Lameere did not study, and, in a specialized Lower Permian member of this family, all these veins can be seen linked up with $R+M$. The problem as to how two of them have disappeared in the Odonata has recently been simplified by the discovery of *Kennedya mirabilis* Till.*, a fine Odonate wing from the Lower Permian of Kansas (fig. F3). In the basilar space, between $R+M$ above and Cu_2+1A below, the missing Cu_1 can be seen as a delicately chitinized, convex vein, connected basally with Cu_2, and ending up at the level of Ac. There is no sign of the lower portion of the media, while the upper or convex portion is connected with Rs as in all recent Odonata. Accepting, then, the cumulative evidence brought forward by this new fossil, by a study of the Protagriidae, and by the argument of Lameere, it is *now possible to offer a New Notation for the venation of the Order*; this notation is given, together with Needham's Notation and the older, classical Selysian System, in the appended Table:—

New Notation		Convex (+) or Concave (−)	Needham's Notation	Selysian System
Costa	C	+	C	Costal nervure
Subcosta	Sc	−	Sc	Subcostal nervure
Radio-median	$R+M$	+	$R+M$	Median nervure
Radius (main stem)	R_1	+	R_1	Median nervure
Arculus vein	$Rs+M$	−	M	Arculus
Radial sector	Rs	−	M_{1-3}	Upper sector of arculus
	R_2	−	M_1	Principal sector
	IR_2	+	M_{1a}	Postnodal sector
	R_3	−	M_2	Nodal sector
	IR_3	+	$Rs\ (Ms)$	Subnodal sector
	R_{4+5}	—	M_3	Median sector
Anterior Median	MA	+	M_4	Lower sector of arculus
Posterior Median	—	—	—	————
First Cubitus†	Cu_1	+	—	————
Second Cubitus	Cu_2	−	Cu_1	Superior sector of triangle
First Anal	$1A$	+	Cu_2	inferior sector of triangle
Cubito-anal	Cu_2+1A	—	Cu	Submedian nervure
Secondary Anal	A'	+	A	Postcostal nervure

In order to understand the stages of the evolution of the Odonate wing, fig. F3 must be compared with the three primitive venational types shown in fig. F4. We shall then be able to state the following facts:—

(1) The subcosta, Sc, was originally a very short vein, ending up at the nodus, N. The flexible nodus of recent Odonata has clearly been formed by addition of a short strut or cross-vein beneath the end of Sc, and an additional oblique cross-vein continuing the formation below R_1 forms the *subnodus*, Sn.

*Named and described by me in "Kansas Permian Insects, pt.v, Protodonata and Odonata", *Amer. Journ. Sci.*, July, 1925.

†Absent in all fossil and recent Odonata except the Lower Permian fossil *Kennedya mirabilis* Till.

(2) Radius and media are fused together from base to *arculus* (*arc*), though their tracheae remain separate in the larval wing-sheath. At the arculus, the fused radial sector (*Rs*) and anterior median of Lameere (*MA*) leave R_1, *Rs* forming the upper sector of the arculus and *MA* the lower. The posterior or concave branch of *M*, which is the true *M* of other recent Orders, is entirely absent, as is also the convex Cu_1, except only in *Kennedya*, where it exists in a reduced state.

(3) Originally there were only two antenodals (Ax_1 and Ax_2). This number remains constant in the more primitive families of Zygoptera, but increases in the higher families of that Suborder (Agrioidea) and in all the Anisoptera.

(4) The number of postnodals was originally small (4 in *Kennedya*, 5-6 in *Hemiphlebia*) and these were not arranged in line with

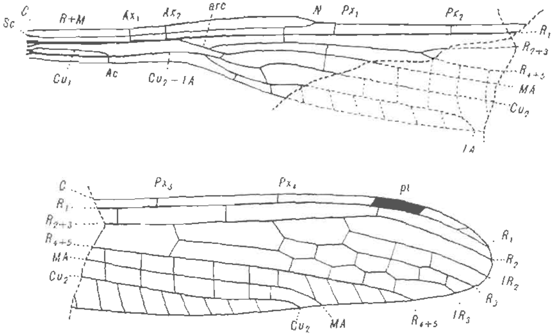


FIG. F3. *Kennedya mirabilis* Till., Lower Permian of Kansas, showing the two preserved parts of the wing, with the missing veins dotted in. Lettering as in fig. A8, p. 22, and in New Notation of Table on p. 68, except *Ac*, anal crossing; *arc*, arculus; Ax_1, Ax_2, the two antenodals; *N*, nodus; *pt*, pterostigma; Px_1-Px_4, the four postnodals. Total length of wing, about 44mm. [*R. J. T. del.*

the cross-veins beneath them. All existing Zygoptera with two antenodals (superfamily Coenagrioidea) have the postnodals arrauged more or less completely in line with the cross-veins beneath them, with the sole exception of *Hemiphlebia*.

(5) The most primitive Odonata had no discoidal cell, but only a single cross-vein joining *MA* to Cu_2 in that region. The first known discoidal cell is that of *Triassolestes* (fig. F4, A) in the form of an irregular quadrilateral (*q*). A simple quadrilateral, of varied shape, characterizes the whole of the most primitive of existing Suborders, the Zygoptera.

(6) The cross-vein *Ac* is constant throughout the Odonata, and indicates the point at which the reduced trachea *1A* in the larval wing-sheath ceases to run alongside trachea *Cu*, which has captured the distal portion of *1A* in the same way that trachea *M* has captured *Rs*.

(7) Originally the Odonata had no secondary anal vein *A'* and no anal field (*af*); both are absent, not only in *Kennedya*, but also in the Upper Triassic *Triassolestes*. The first stage in their development is to be seen in *Chorismagrion* (fig. F4, B), and a slightly more advanced stage in *Synlestes* (fig. F8) and *Argiolestes* (fig. F9); in *Austrolestes* (fig. F10) and *Pseudagrion* (fig. F7) *A'* and consequently *af* also, extends backwards as far as *Ac*; in the otherwise primitive *Hemiphlebia* (fig. F4, C) and in many more advanced types (e.g., fig. F12),

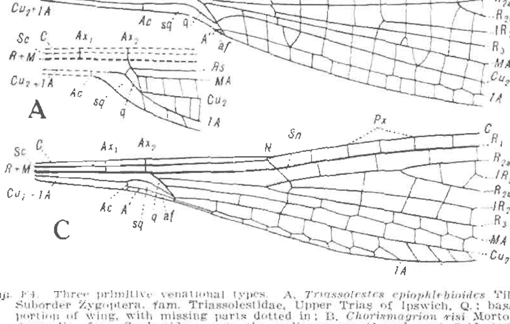


Fig. F4. Three primitive venational types. A, *Triassolestes epiophlebioides* Till., Suborder Zygoptera, fam. Triassolestidae, Upper Trias of Ipswich, Q.; basal portion of wing, with missing parts dotted in; B, *Chorismagrion risi* Morton, Australia, fam. Synlestidae; note the rudimentary *A'* and anal field (*af*), absent in *Triassolestes* and in fig. F3; C, *Hemiphlebia mirabilis* Sel., Australia, fam. Hemiphlebiidae; note the well-formed *A'* and *af* and the lack of correspondence between the postnodals and the cross-veins below them (*cf.* fig. F3); B and C represent forewings; in the corresponding hindwings, the quadrilateral is closed, as in A. Lettering as in fig. F3, except *q*, quadrilateral; *Sn*, subnodus; *sq*, subquadrangle. [*R. J. T. del.*

Ac falls definitely on to *A'* instead of on to the posterior margin of the wing. In the Libellaginidae (fig. F13) *A'* passes backwards well beyond *Ac*, while in the Agriidae (fig. F14), *A'* has at last reached the base of the wing, forming a complete *secondary anal* vein, with consequent development of a large triangular anal field, *af*, beneath it. In all Anisoptera, *A'* reaches the base of the wing, but the form of the anal field takes different lines of specialization in fore and hind wing.

(8) An *oblique vein* (figs. F8, F10, *O*), indicating the point where an adventitious trachea from R_s begins to supply the line of IR_3 in the larval wing, is not present in the oldest Odonata, but is often present (not constant) in Synlestidae. In the Lestidae it becomes a constant character; the portion of IR_3 from its origin on R_2 up to *O* has been termed the *long bridge*. In the oldest Anisoptera the adventitious trachea descends from the subnodus and branches into two; one of these runs along R_2 to *O*, where it descends on to IR_3, while

another shorter branch descends almost at once at the point of *O'* (Petaluridae, pl. 4, fig. 1). In the higher families of Anisoptera, *O* becomes aborted and only *O'* remains; the part of IR_3 from its origin on R_2 up to *O'* is then called the *bridge-vein*. By this term Needham sought to convey his belief that the vein originally arose at *O'* and gradually became built backwards to below *Sn*; but the fossil record shows that the course of evolution was the other way round.

(9) The veins labelled IR_2 and IR_3 were interpolated as new sectors (convex) between the original concave branches of *Rs*, before the Order Odonata was evolved. They are present in the most primitive Odonata and persist throughout the Order; but IR_2 tends to obsolescence in the highest Anisoptera, while IR_3 is sometimes attached to R_{4+5} instead of to R_{2+3}, as in *Synlestes* (fig. F8).

(10) The *pterostigma* (*pt*) was present in the earliest Odonata as a thickened, elongate cell. It becomes specialized both by the development of a brace-vein (figs. F8, F10, *bv*) and by alteration of shape; in some groups, reduction leads finally to complete loss (males of Agriidae).

The above rather detailed discussion of the admittedly difficult problem of the venation of this Order is given in the hope that it may assist the student to follow the scheme of classification, which is based chiefly on the venation itself.

A b d o m e n always elongated, generally considerably so, either cylindrical, clubbed distally, or more or less flattened dorso-ventrally; in Anisoptera the third segment is often constricted (fig. F1), and, in those males with angulated hindwings, the second tergite carries a pair of small protuberances termed *auricles* (fig. F1, *au*). There are ten well-developed segments with complete tergites and sternites, the former extending downwards laterally and ventrally, so as to hide the pleural membrane and spiracles and also partially to overlap the sternites. *Cerci* short, unsegmented, forming the *superior appendages* of systematists, in both sexes. *Supra-anal plate* present in males of Anisoptera, where it forms the *inferior appendage* of systematists, vestigial in males of Zygoptera and in all females. *Paraprocts* present, but only strongly chitinized in males of Zygoptera, where they form the paired *inferior appendages* of systematists. Females of all Zygoptera and some Anisoptera with a complete, primitive *ovipositor* (fig. A10) formed from the three pairs of gonapophyses, the gonocoxites (=lateral processes or valves) carrying styles; in some Anisoptera the ovipositor is reduced or vestigial. Males with the gonopore apparently on ninth sternite, but actually situated between it and the sutural membrane between segs. 9 and 10, which has become chitinized into a hard plate; gonocoxites present, reduced to small valves without styles, but parameres and primitive penis absent. The *functional penis*, with complicated accessory armature, is developed in a groove of the second sternite (fig. F1, B, *ag*); this formation is unique within the Insecta. *Spiracles* eight pairs, on segs. 1-8. *Malpighian tubules* numerous.

In practice, female Odonata can always be distinguished by having only two terminal appendages, whereas the males possess either three (Anisoptera) or four (Zygoptera); the males can always be recognized by the presence of the groove and functional penis situated in the second abdominal sternite.

Life History. In their early stages, dragonflies are aquatic, their larvae breathing by means of tracheal gills. The *eggs* are laid either in the tissues of aquatic plants and of other plants growing near water, or are washed out freely by the female as she flies, by dipping her abdomen into the water. They hatch out into a tiny, swathed larvule, termed a *pronymph*, which in less than a minute casts off its skin and appears as a free-swimming larva, often called a *naiad* or *nymph*. These larvae (figs. F5, F11, F20, F21) are of very varied form, but are all highly carnivorous; they grow rapidly, feeding upon protozoa, small crustacea, insect larvae, etc., by means of their powerful *mask* (fig. F5, B-D), which consists of the highly specialized *labium* elon-

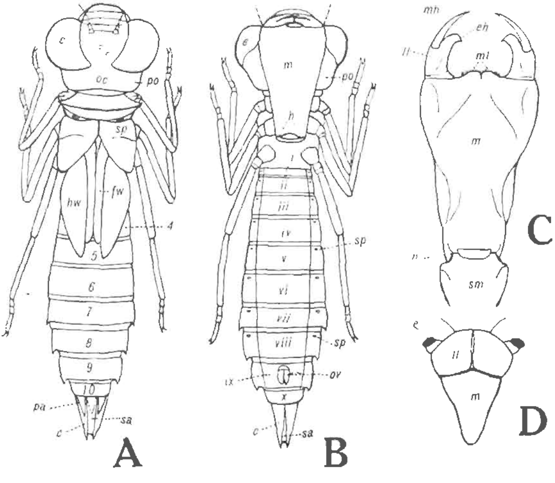


FIG. F5. A, larva of *Aeschna brevistyla* Ramb., Australia and N.Z., fam. Aeschnidae, dorsal view (× 2); B, the same, ventral view; C, labial mask of same, extended (× 3.3); D, ventral view of head of larva of *Tramea loewii* Br. (× 3), to show the large, spoon-shaped mask covering the whole of the face except the eyes, which are on raised protuberances; *4-10*, abdominal tergites; *i-x*, abdominal sternites; *c*, cercus; *e*, eye; *eh*, end-hook; *fw*, forewing; *h*, hinge; *hw*, hindwing; *ll*, lateral lobe; *m*, mentum; *mh*, movable hook; *ml*, median lobe; *oc*, occiput; *ov*, ovipositor; *pa*, paraproct; *po*, postocular lobe; *sa*, supra-anal plate; *sm*, submentum; *sp*, spiracle.

[*R. J. T.* del.

gated into the form of an arm, and jointed between mentum and submentum along a hinge (fig. F5, *C*, *h*). This weapon can be shot out rapidly, the movable hooks (*mh*) on the lateral lobes being extended at the same time, and then as quickly withdrawn with the hooks firmly fixed in the body of the victim. The shape of the mask, and, in par-

ticular, the structure of the lateral lobes, are valuable characters in defining the families. The larvae pass through twelve or more instars, the wing-sheaths developing in such a way that the hindwing comes to overlie the fore (fig. F5, A). Respiration is carried out either by means of three caudal gills, situated on the two paraprocts and the supra-anal plate (Zygoptera) or by a complex system of rectal gills (Anisoptera); very rarely there are paired lateral gills on some of the abdominal segments. The larvae possess a strong gizzard armed with internal teeth, whose structure and arrangement have been made use of for classification. When full-fed, the larva rests awhile, and then climbs up out of the water, disclosing the perfect insect and leaving the tough exuviae clinging to a stem or rock; the wings of the imago develop rapidly and harden in the sun.

In pairing, the male seizes the female either by the prothorax (Zygoptera) or the back of the head (Anisoptera) by means of his terminal appendages, and the two may indulge in a nuptial flight, tandem-wise. Previously to this, the male has transferred the sperm from the gonopore on seg. 9 into the penis-sac on seg. 2; the female has therefore to bring her abdomen forward beneath that of the male, so as to connect up with the copulatory apparatus of the second segment.

Distribution. Dragonflies are numerous in Australia, the number of known species being just over 200. In New Zealand, in spite of the abundance of running water, only thirteen species are known; four of these are found also in Australia, while all the rest are closely related to Australian forms. The majority of the Australian species are tropical or subtropical, and are derived from the Oriental fauna; but there also exist a number of archaic remnants, not found elsewhere together with a very considerable autochthonous fauna, particularly rich in Gomphidae and Corduliidae.

Fossil History. The earliest known true Odonata occur in the Lower Permian of Kansas, where the Order is represented by two genera with slender, petiolate wings, much resembling those of existing Zygoptera, but sufficiently distinct to require a new Suborder (Protozygoptera) for their reception; the better preserved of the two, *Kennedya*, is shown in fig. F3. In the Upper Trias of Ipswich, Q., several genera are found, only two of which have the basal part of the wing preserved; both these wings are petiolate. One of them is *Triassolestes* (fig. F4, A), a true Zygopteron related to the Synlestidae, but without A' and *af*; the other is *Triassagrion*, a member of the very distinct Suborder Archizygoptera confined to the Trias and Lias. In the Lias of Europe true Zygoptera were present, but the great majority of the genera so far discovered belong to the now almost extinct Suborder Anisozygoptera, intermediate between true Zygoptera and Anisoptera. True Anisoptera first appear in the Upper Jurassic, most of the forms being allied to the Petaluridae and Gomphidae. Numerous Tertiary fossil Odonata are known, chiefly from the Miocene of Florissant, Colorado, and the South of England.

Economics. Dragonflies are to be reckoned as wholly beneficial insects, on account of the immense number of noxious insects, such as flies, mosquitoes, etc., which are destroyed by them both in their larval and imaginal stages. Both larvae and imagines also form an excellent food for fishes.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order ODONATA 201 (13)

Suborder ZYGOPTERA 71 (5)

I. COENAGRIOIDEA 65 (5)
1. HEMIPHLEBIIDAE 1 (0) (PLATYCNEMIDAE)
2. PROTONEURIDAE 9 (0)
3. COENAGRIIDAE 23 (4)
4. SYNLESTIDAE 5 (0)
5. MEGAPODAGRIIDAE 15 (0)
6. LESTIDAE 12 (1) (PSEUDOSTIGMATIDAE)

II. AGRIOIDEA 6 (0)
7. AMPHIPTERYGIDAE 4 (0)
8. LIBELLAGINIDAE 1 (0) (EPALLAGIDAE) (POLYTHORIDAE)
9. AGRIIDAE 1 (0)

Suborder ANISOZYGOPTERA { (EPIOPHLEBIOIDEA) (EPIOPHLEBIIDAE)

Suborder ANISOPTERA 130 (8)

III. AESCHNOIDEA 54 (3)
10. PETALURIDAE 3 (2)
11. GOMPHIDAE 20 (0) (CORDULEGASTERIDAE)
12. AESCHNIDAE 31 (1)

IV. LIBELLULOIDEA 76 (5)
13. CORDULIIDAE 37 (4)
14. LIBELLULIDAE 39 (1)

Specialists in this Order have only hitherto recognized four or, at the most, five, families, which are further subdivided into a number of strongly marked subfamilies. These latter, being the units which clearly correspond with the families of other Orders in rank, are therefore considered as families here, while the four original families are raised to superfamily rank. There are three existing Suborders, which can be separated as follows:—

1. Fore and hind wings closely similar both in shape and venation. Suborder ZYGOPTERA

   Fore and hind wings differing more or less markedly in shape and venation 2

2. Discoidal cell a simple quadrilateral, but markedly different in form in fore and hind wings. Suborder ANISOZYGOPTERA

   Discoidal cell divided into supra-triangle and triangle. Suborder ANISOPTERA

The Anisozygoptera consist, at the present day, of a single family Epiophlebiidae containing a single genus *Epiophlebia* with two species, one found in Japan and the other in the Himalayas. They need not, therefore, be further considered in this work. All the Australian and New Zealand species in which the discoidal cell is a simple quadrilateral belong to the Zygoptera.

Suborder ZYGOPTERA

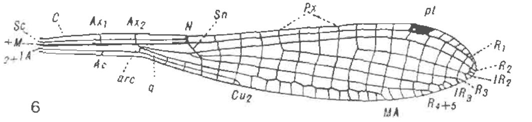
(Damsel-flies)

With few exceptions, the members of this Suborder rest with their wings closed in a vertical plane above the abdomen. A complete ovipositor is always present in the female. The larvae are slender in build, and breathe by means of three caudal gills, situated on the paraprocts and the supra-anal plate. In

·lassification, the form of the discoidal cell or quadrilateral (*q*), the sub-·uadrangle (*sq*) and the anal field (*af*) are of importance, as well as the position ·f the arculus (*arc*) and nodus (*N*) and the number of antenodals (*Ax*). There ·re two superfamilies, distinguished as follows:—

Antenodals two only*; subquadrangle a simple cell*; arculus either nearer to nodus than to base, or about equidistant from both.
I. COENAGROIDEA.

Antenodals five or more; subquadrangle usually reticulate; arculus nearer to base than to nodus*.
II. AGRIOIDEA



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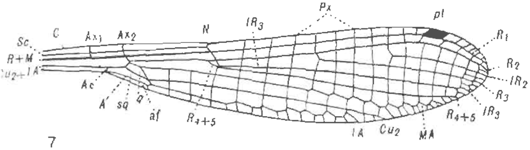
·IG. F6. Forewing of *Neosticta canescens* Till., Australia, fam. Protoneuridae. Lettering as in fig. F3, except *q*, quadrilateral; *Sn*, subnodus. [*R. J. T. del.*



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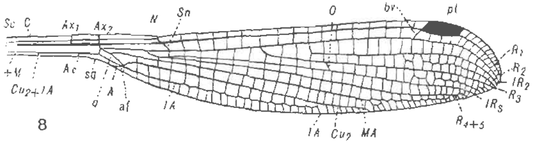
·IG. F7. Forewing of *Pseudagrion australasiae* Sel., Australia, fam. Coenagriidae. Lettering as in previous figure, except A', secondary anal vein; *af*, anal field; *sq*, subquadrangle. [*R. J. T. del.*



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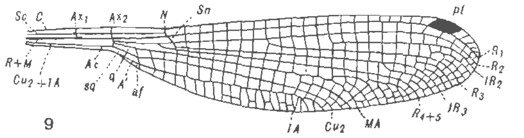
·IG. F8. Forewing of *Synlestes weyersi* Sel., Australia, fam. Synlestidae. Lettering as in previous figure, except *bv*, brace-vein; *O*, oblique vein. [*R. J. T. del.*



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·IG. F9. Forewing of *Argiolestes icteromelas* Sel., Australia, fam. Megapodagriidae. Lettering as above. [*R. J. T. del.*

*One or two exceptions to these characters occur in anomalous genera not ·ound in our fauna.

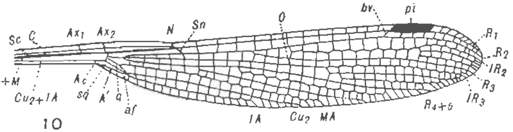

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FIG. F10. Forewing of *Austrolestes cingulatus* Burm., Australia, fam. Lestidae. Lettering as in previous figures. [*R. J. T. del.*

Superfamily I. COENAGRIOIDEA*

This group, equivalent to the old family Agrionidae of de Selys, contains the simplest and most primitive of living Odonata, all of them being slender-bodied damsel-flies with petiolate wings. Under the new classification it includes no less than eight families, six of which occur in Australia, but only two in New Zealand. They can be distinguished as follows:—

1. Cu_2 leaving the sharply acute distal angle of quadrilateral with a strong upward arching. Fam. 4. SYNLESTIDAE
   Cu_2 not as above, but either straight or only slightly arched. 2
2. No supplementary sectors present running inwards from distal portion of posterior margin of wing. 3
   One or more supplementary sectors present. 5
3. *1A* absent, Cu_2 reduced in length Fam. 2. PROTONEURIDAE
   1A and Cu_2 both normal. 4
4. Postnodals not in line with cross-veins beneath them; quadrilateral of forewing open basally. Fam. 1. HEMIPHLEBIIDAE
   Postnodals in line with cross-veins beneath them as far as *M*; quadrilateral of forewing normal. Fam. 3. COENAGRIIDAE
5. R_{4+5} and IR_3 arising closer to arculus than to nodus; an oblique vein (*O*) present, far distad from nodus, between R_3 and IR_3; distal angle of quadrilateral very acute. Fam. 6. LESTIDAE
   R_{4+5} and IR_3 arising closer to nodus than arculus, IR_3 usually beneath *Sn*; no oblique vein present; distal angle of quadrilateral much less acute, usually blunt. Fam. 5. MEGAPODAGRIIDAE

Family 1. **Hemiphlebiidae** [Aus. 1, N.Z. 0]. The only known species is the tiny Australian *Hemiphlebia mirabilis* Sel. (fig. F4, C), a rare insect having a slender, metallic green body, less than an inch long, and very short wings, 10-12 mm. long. The male has forcipate superior appendages and long, white, ribbon-like inferior appendages, which it displays to the female during courtship. It is probably the most archaic Odonate still existing, but is specialized in the form of *A'* and *af*, in which it resembles the Coenagriidae. The life-history is quite unknown.

Family 2. **Protoneuridae** [Aus. 9, N.Z. 0]. Quadrilateral narrow, rectangular; *A'* and *af* absent in all the Australian forms; pterostigma short; cross-veins arranged in transverse series from costa to *MA*, this latter vein being zig-zagged distally. Appendages of male variable, both pairs often more or less forcipate. Larvae with caudal gills usually constricted in the middle, the mask with cleft median lobe and lateral lobes of Coenagriid type (fig. F11, A).

There are six Australian genera, all peculiar to that region except one. The best known species is *Nososticta solida* Sel., orange and black in colour, with basal portions of wings stained a bright yellow. The duller coloured *Isosticta simplex* Mart. and *Neosticta canescens* Till. (fig. F6) are not uncommon in Eastern Australia. *Caconeura* and *Oristicta* are confined to the Tropics, while *Austrosticta fieldi* Till. has only been found in the ranges of Central Australia. All the species are of very slender, delicate build, expanding from 30 to 50 mm.

Family 3. **Coenagriidae*** [Aus. 23, N.Z. 4]. Small to medium-sized damsel-flies with wings having the cross-veins in transverse series as in previous family, but Cu_2 and *1A* normal; *MA* and *1A* both markedly zig-zagged distally; quadrilateral more or less acutely angled distally; pterostigma short; *A'* and *af* present, extending basad as far as the petiole. Appendages of male short, highly specialized, not forcipate. Larvae with simple lamellar gills held in the

*See footnote on p. 80.

vertical plane; mask with prominent median lobe, not cleft, and lateral lobe as in fig. F11, B.

Three subfamilies of this extensive group, dominant amongst present-day Zygoptera, are represented in Australia. The slender Teinobasinae have the wings petiolate almost to the level of Ax_1, and *af* very small; they are represented only by tropical species of the genera *Teinobasis*, *Archibasis* and *Aciagrion*. The Pseudagriinae, in which *Ac* falls on to, or just basad from, the basal end of *A'* are represented by the genera *Austroagrion*, *Pseudagrion*, *Caliagrion* and *Xanthagrion* in Australia and by *Xanthocnemis* in New Zealand; the

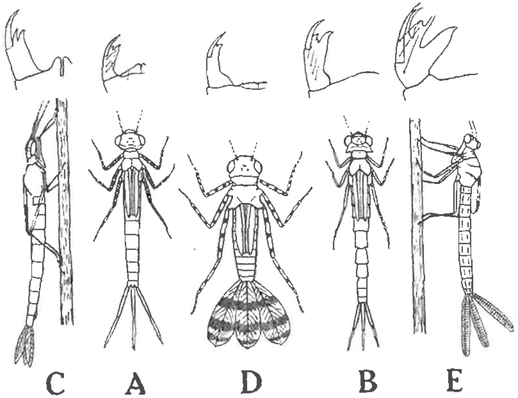


FIG. F11. Larvae of Coenagrioidea. A, *Isosticta simplex* Mart., Australia, fam. Protoneuridae (× 1.8); B, *Caliagrion billinghursti* Mart., Australia, fam. Coenagriidae (× 1.2); C, *Synlestes weyersi* Sel., Australia, fam. Synlestidae (× 1.2); D, *Argiolestes icteromelas* Sel., Australia, fam. Megapodagriidae (× 1.3); E, *Austrolestes cingulatus* Burm., Australia, fam. Lestidae (× 1.5). Above the figure of each larva is placed an enlargement of the median and left lateral lobes of its mask. [*R. J. T. del.*

only common Coenagriid in this latter country is the pretty red *X. zelandica* Sel. (pl. 2, fig. 3). *Xanthagrion erythroneurum* Sel. is a pretty Australian species, widely distributed, in which the male has a red thorax and blue tip to the abdomen. *Caliagrion billinghursti* Mart. is a fine species expanding 2½ inches, with bright blue abdomen in the male; it is confined to South-eastern Australia. The genus *Pseudagrion* contains pretty tropical and subtropical species, the commonest being the blue and bronze *Ps. australasiae* Sel. (fig. F7); the lovely orange and blue *Ps. aureofrons* Till. and the larger, dark-coloured *Ps. ignifer* Till. (pl. 3, fig. 1) with reddish face, are somewhat rare insects. *Austroagrion* contains much smaller blue and bronze species, of which the Eastern Australian *A. cyane* Sel. is exceedingly common. The Coenagriinae have *Ac* falling upon the basal part of *A'*, as in Hemiphlebiidae. The commonest genus is *Ischnura*; *I. heterosticta* Burm. is a very common species with the abdomen of the male bronze, tipped with bright blue; the smaller and very beautiful *I. aurora* Br. has a red abdomen with blue tip in the male, and occurs throughout Australia, Norfolk, Lord Howe and Kermadec Islands, as well as occasionally in New Zealand. The genera *Agriocnemis* and *Austrocnemis* contain the midgets amongst damsel-flies, the smallest species expanding only 18 mm. Most of the genera of this subfamily have dimorphic females, one form being dull and protectively coloured, while the other is either bright orange or resembles the male.

Family 4. **Synlestidae** [Aus 5, N.Z. 0]. Quadrilateral long, narrow, sharply angulated distally, with Cu_2 arising from that angle by a strong upward arching; except in the Indian genus *Megalestes*, R_{4+5} and IR_3 are closer to nodus than to arculus; these two veins always closely converge distally; oblique vein sometimes present; pterostigma variable; supplementary sectors present or absent, only well developed in the African genus *Chlorolestes*; A' and *af* very small except in *Megalestes* (entirely absent in the Neotropical genus *Perilestes*). Superior appendages of male forcipate. Larvae (*Synlestes*) very long and slender, with pedicel of antenna much elongated; mask long, with cleft median lobe and lateral lobe as in fig. F11, C; caudal gills lamellar, lanceolate, held in a vertical plane. A small family of archaic types, represented in Australia by *Synlestes* (fig. F8) and *Chorismagrion* (fig. F4, B); the latter genus, like *Hemiphlebia*, has the quadrilateral of the forewing open basally. *Synlestes weyersi* Sel. (pl. 3, fig. 2), with several subspecies, is a long-bodied, slender, metallic green damsel-fly expanding 60-75 mm., not uncommon in Eastern Australia.

Family 5. **Megapodagriidae*** [Aus. 15, N.Z. 0]. Quadrilateral medium to long, with medium to short distal side and more or less blunt distal angle, from which Cu_2 arises as a straight or only slightly arched vein; R_{4+5} and IR_3 closer to nodus than to arculus, IR_3 usually below Sn; these veins usually diverging distally, rarely converging; oblique vein absent; A' and *af* usually small, seldom reaching Ac; supplementary sectors always present and well developed; pterostigma variable. Superior appendages of male forcipate. Larva (*Argiolestes*) rather short and stout; mask with median lobe entire, lateral lobe as in fig. F11, D; caudal gills broad, leaf-like, forming an anal fan held in the horizontal plane. Nearly all the Australian species belong to the genus *Argiolestes* (fig. F9), the commonest being the dull, blackish *A. icteromelas* Sel. (pl. 3, fig. 3), found everywhere on rocky streams, and the smaller mountain species *A. griseus* Sel. *A. amabilis* Foerster and *A. chrysoides* Till. are mountain species beautifully marked with dark red and orange-red respectively. All the members of this and the succeeding genus rest with wings outspread, as in the Anisoptera. *Podopteryx roseonotata* Sel. (pl. 3, fig. 4), a rare insect from North Queensland, called "Wongera-wongera" by the aborigines, is rich black, with rosy spots on prothorax, and expands about 4 inches. The aberrant genus *Lestoidea*, placed here provisionally in a separate subfamily Lestoideinae, perhaps deserves family rank; it has Cu_2 reduced and IA absent, as in Protoneuridae, R_{4+5} and IR_3 nearer to arculus than to nodus, and a single strong supplementary sector between R_2 and IR_2.

Family 6. **Lestidae** [Aus. 12, N.Z. 1]. Quadrilateral narrow, elongate, with sharply acute distal angle; Cu_2 leaving that angle as a straight vein or nearly so; A' and *af* well developed, Ac falling on or near base of A'; R_{4+5} and IR_3 arising closer to arculus than to nodus, diverging distally and separated by supplementary sectors; a number of these latter present, well developed, some straight, some zig-zagged; an oblique vein (fig. F10, *O*) present between R_3 and IR_3 well distad from nodus; pterostigma elongate; cross-veins not markedly arranged in transverse series. Superior appendages of male forcipate. Larvae with highly specialized mask having the lateral lobe broadened, concave, irregularly toothed, the movable hook carrying setae, (fig. F11, E); gills long, well-rounded apically, with their branch tracheae arising at right-angles to the main longitudinal ones; these larval characters are high specializations, peculiar to the group. A world-wide family represented in both countries by the genus *Austrolestes* (fig. F10); most of the species are bronze and blue, expanding about 2 inches. *A. colensonis* Wh., one of the largest species, is abundant throughout New Zealand in swamps and marshy places. The commonest Australian species are *A. leda* Sel. and *A. analis* Ramb., the latter being remarkable in retaining an immature pinkish colouring instead of blue for most of its life. *A. annulosus* Sel., common in the south and south-west of Australia and also in Tasmania, is a handsome species with bronze arrowheads on the blue abdominal segments of the male. *A. cingulatus* Burm. (pl. 3, fig. 5) is a handsome, metallic green, mountain species. Unlike the Lestidae of other countries, the Australian and New Zealand species rest with wings entirely closed.

Superfamily II. AGRIOIDEA.*

The members of this group, which is equivalent to the old family Calopterygidae* of de Selys, are the more specialized damsel-flies in which petiolation of the wing has become lessened or entirely lost, with correlated lengthening of A' and

* *See footnote on p. 80.

enlargement of *af*; the two original antenodals are increased by at least three additional ones placed further distad, and usually by many more; the nodus tends to move further away from the base of the wing, and R_{4+5} and IR_3 are always much closer to arculus than to nodus (as in Lestidae); supplementary sectors are always present and usually very numerous; the males have forcipate superior appendages. The origin of the group as a whole must have been from the common stem of the Synlestidae, Megapodagriidae and Lestidae. Five families may be recognized, of which the Epallagidae and Polythoridae are not represented in our fauna, while the other three are but poorly represented in Australia, and are entirely absent from New Zealand; they may be distinguished as follows:—

1. Wings distinctly petiolate up to base of *A'*, with a marked angle between petiole and posterior margin at that point; extra antenodals few in number and often incomplete (i.e., between *C* and *Sc* only).
   Fam. 7. Amphipterygidae
   Not as above. 2
2. Wings subpetiolate, the narrow basal portion widening insensibly from the level of Ax_1, with no marked angle between petiole and posterior margin at base of *A'*. Fam. 8. Libellaginidae
   Wings without petiole; the whole wing, including the enlarged *af*, densely reticulate, with pterostigma frequently atrophied in male.
   Fam. 9. Agriidae

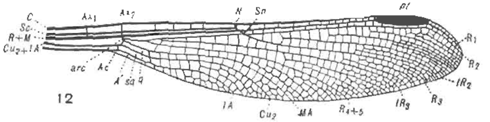
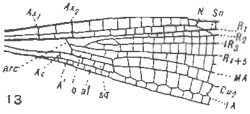


Fig. F12. Forewing of *Diphlebia lestoides* Sel., Australia, fam. Amphipterygidae. Lettering as in Figs. 6-8. [R. J. T. del.



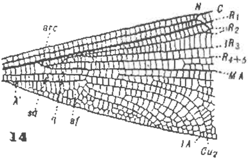


Fig. F13. Basal portion of forewing of *Rhinocypha tincta* Ramb., female, Australia, fam. Libellaginidae. Lettering as above.

Fig. F14. Basal portion of forewing of *Neurobasis chinensis australis* Sel., female, fam. Agriidae. Lettering as above. [R. J. T. del.

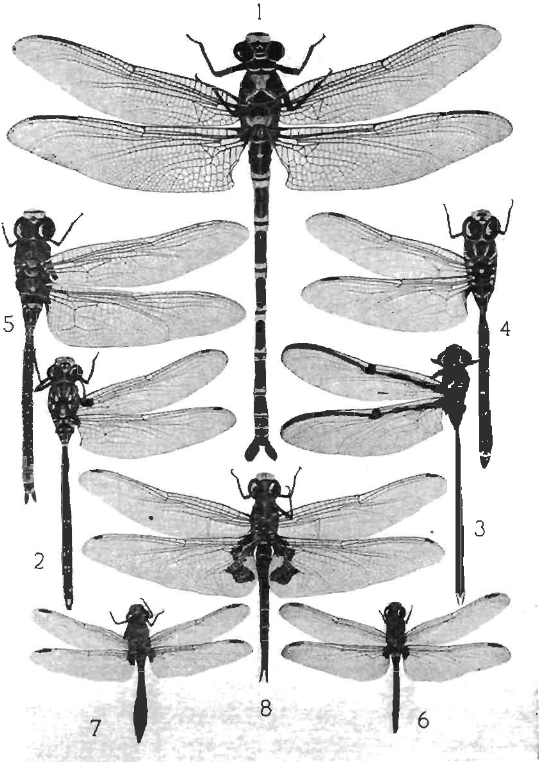
Family 7. **Amphipterygidae** [Aus. 4, N.Z. 0]. This primitive family, obviously related to the families Synlestidae, Megapodagriidae and Lestidae, is represented in Australia by four species of the archaic genus *Diphlebia* (fig. F12), which contains beautiful, bright blue, or blue and black, damselflies with an expanse of about 3 inches; they rest on rocks, twigs, etc., near running water with their wings outspread as in Anisoptera. Their larvae (fig. F15) cling to rocks in running water, and are peculiar in having swollen, saccoid caudal gills which are easily detached and frequently lost; the mask is short, with slightly cleft median lobe, and lateral lobe like that of *Synlestes*, but with an extra tooth (fig. F15). *D. lestoides* Sel. (pl. 3, fig. 6), the commonest species,

PLATE 4

AUSTRALIAN ODONATA (ANISOPTERA)

All figures slightly reduced

1. *Petalura pulcherrima* Till. (Fam. PETALURIDAE), male.
2. *Austroaeschna parvistigma* Sel. (Fam. AESCHNIDAE), male.
3. *Telephlebia godeffroyi* Sel. (Fam. AESCHNIDAE), male.
4. *Aeschna brevistyla* Ramb. (Fam. AESCHNIDAE), male (Australia and N.Z.).
5. *Anax papuensis* Burm. (Fam. AESCHNIDAE), male.
6. *Diplacodes melanopsis* Mart. (Fam. LIBELLULIDAE), male.
7. *Austrothemis nigrescens* Mart. (Fam. LIBELLULIDAE), male.
8. *Tramea loewii* Br. (Fam. LIBELLULIDAE), female.



'. C. Davies photo.

AUSTRALIAN ODONATA (ANISOPTERA)

has a bright blue abdomen in the male, and the wings are often crossed by a milk-white bar. The rare *D. euphoeoides* Till. (pl. 11, fig. 1) from Queensland is a much darker insect with blackish wings.

Family 8. **Libellaginidae** [Aus. 1. N.Z. 0]. A small but interesting family centred in India and Africa, and barely represented in Australia by the single species *Rhinocypha tincta* Ramb. (fig. F13), which has been taken in North Queensland.

Family 9. **Agriidae (Calopterygidae)*** [Aus. 1. N.Z. 0]. This, the dominant and most highly specialized family of the group, abundant throughout tropical countries, is barely represented in Australia by the very handsome *Neurobasis chinensis australis* Sel. (fig. F14), which occurs very rarely in North Queensland. The basal two-thirds or more of the hind wings in the male are a brilliant, metallic bluish-green.

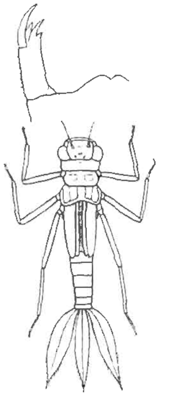


FIG. F15. Larva of *Diphlebia lestoides* Sel., fam. Amphipterygidae (× 1.3). Above, an enlargement of median and left lateral lobes of mask. [*R. J. T. del.*

Suborder ANISOPTERA

(Dragonflies)

This Suborder contains the stouter, and, for the most part, larger species of the Order, to which the name "dragonfly" more properly applies. With the single exception of the Australian genus *Cordulephya* (pl. 5, fig. 6), which rests with wings folded like a damselfly, all the species rest with wings outspread in the horizontal plane, or somewhat depressed below the level of the body. As with the Agriidae, so throughout the Anisoptera, the anal field is so much enlarged that petiolation of the wings is entirely lost, the vein *A'* running back to the very base of the wing, and forming a complete *secondary anal vein*. At the extreme base of *A'*, the posterior margin is bordered by a small piece of opaque membrane, called the *membranule* (*mb*). In the great majority of forms, *A'* is further specialized by arising distally from the posterior angle of the triangle instead of from slightly below it; an oblique cross-vein between it and the basal angle of the triangle also usually marks off a more or less distinct cell, the *subtriangle* (*s*). In the forewings of some families, this subtriangle becomes highly specialized (figs. 16, 19), causing *A'* to become bent below the oblique cross-vein which forms the anterior side of *s*; this vein tends to become more and more aligned with the basal portion of *A'* (Petaluridae and Libelluloidea), and, in the highest types of all (*Tramea*, pl. 4, fig. 8) becomes entirely aligned with it, the original distal portion of *A'* becoming obsolete. In the hindwings, a different type of specialization sets in; beginning with increased widening of *af*, we find the cross-veins of this area becoming first of all arranged to form descending branches of *A'* (Petaluridae, Gomphidae), and then a distinct, compact *anal loop* (*al*) becomes marked out (Aeschnidae and some Corduliidae); this loop begins to lengthen parallel to and below *1A* (*Hesperocordulia*, pl. 5, fig. 5) and finally (most Libellulidae) becomes stocking-shaped, with a strong mid-rib, called the *anal supplement* (*Aspl*).

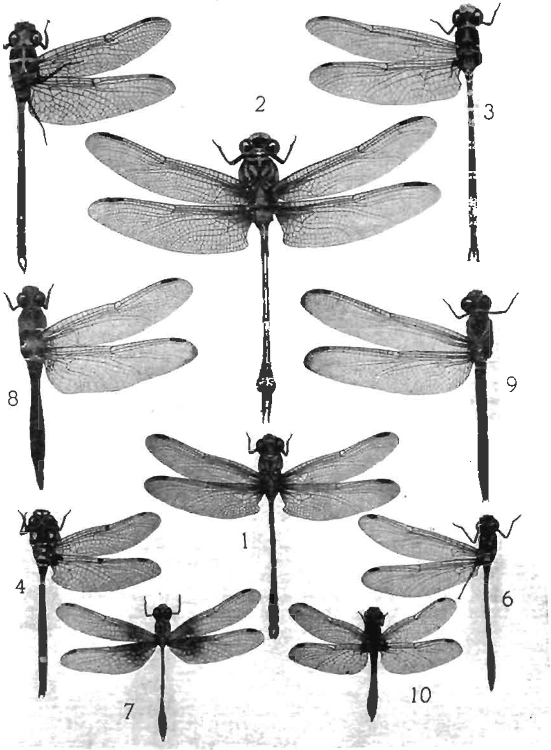
*It is unfortunate that the fine classical name *Calopteryx*, which was in general use unchallenged for three-quarters of a century, has to be discarded by the Law of Priority, the type of the Linnean genus *Agrion* being the insect which had been known for all that time as *Calopteryx virgo* L. The new name required for the genus whose type had been known as *Agrion puella* L. was supplied by Kirby, viz *Coenagrion*, who also changed the family name to Coenagrionidae, by analogy with the old form Agrionidae. The name *Agrion*, however, is derived from Greek *agrias*, wild, neuter *agrion*, a wild thing, stem *agri-*, and hence the correct family names are Agriidae, Coenagriidae, Megapodagriidae, and the superfamily names Agrioidea and Coenagrioidea.

Plate 5

AUSTRALIAN ODONATA (Anisoptera)

All figures slightly reduced

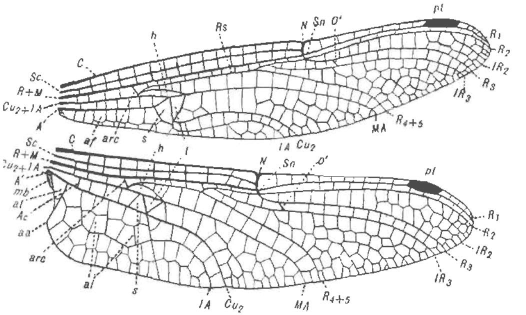
1. *Hemigomphus heteroclitus* Sel. (Fam. Gomphidae), male.
2. *Ictinus australis* Ramb. (Fam. Gomphidae), male.
3. *Synthemis regina* Sel. (Fam. Corduliidae), male.
4. *Synthemiopsis gomphomacromioides* Till. (Fam. Corduliidae), male.
5. *Hesperocordulia berthoudi* Till. (Fam. Corduliidae), male.
6. *Cordulephya montana* Till. (Fam. Corduliidae), male.
7. *Nannophlebia risi* Till. (Fam. Libellulidae), male.
8. *Orthetrum villosovittatum* Br. (Fam. Libellulidae), male.
9. *Lathrecista asiatica festa* Sel. (Fam. Libellulidae), male.
10. *Nannophya dalei* Till. (Fam. Libellulidae), male.



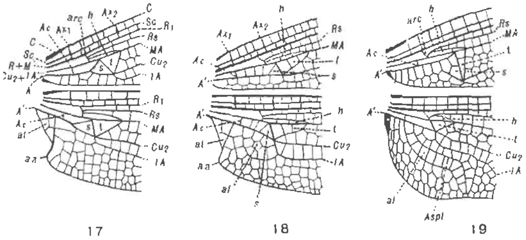
N. C. Davies photo.

AUSTRALIAN ODONATA (ANISOPTERA)

The most important specialization which distinguishes this Suborder is the ıvision of the original discoidal cell or quadrilateral into *supra-triangle* (h) and iangle (t). A study of the Liassic Anisozygoptera reveals the interesting fact ıat this specialization started first in the hindwing, which possessed a broader



ıG. F16. Wings of *Synthemis regina* Sel., Australia, fam. Corduliidae, subfam. Synthemìnae. Lettering as in figs. F6-8, except *aa*, anal angle of hindwing (in male only); *al*, anal loop; *at*, anal triangle (in male only); *h*, supra-triangle or hypertrigonal space; *mb*, membranule; *O'*, oblique vein; *s*, subtriangle; *t*, triangle. [*R. J. T. del.*



ıG. F17. Basal portion of wings of *Hemigomphus heterocl̈itus* Sel., Australia, fam. Australia, fam. Gomphidae. Lettering as in previous figure.
ıG. F18. Basal portion of wings of *Austroaeschna parvistigma* Sel., Australia, fam. Aeschnidae, subfam. Brachytrinae. Lettering as in fig. F16.
ıG. F19. Basal portion of wings of *Orthetrum villosovittatum* Br., Australia, fam. Libellulidae, subfam. Libellulinae. Lettering as in fig. F16.
[*R. J. T. del.*

ıadrilateral than the fore; the dividing cross-vein arose from the basal angle ıd ended on the distal side somewhat below the anterior distal angle. Later on, ıe forewing quadrilateral also became divided, and thus the first true Anisoptera ıd triangles of fore and hindwings somewhat different in shape, (as in etaluridae).

In all Anisoptera, the nodus lies at or beyond half-way in the forewing, ightly nearer the base in the hindwing; just below or beyond *Sn*, between R_3 ıd IR_3 the oblique vein O' can always be found; but the older formation O,

homologous with that of Lestidae, is only present in the Petaluridae (pl. 4, fig. 1) and some Aeschnidae. In the more archaic families, the two original antenodals Ax_1 and Ax_2 of Zygoptera can always be found, as they are more stoutly built than the others; moreover, the rest of the antenodals are not in line with one another in the costal and subcostal spaces. In the higher families (Libelluloidea) this distinction is lost, and all the antenodals become aligned.

The larvae of Anisoptera are always stoutly built and of very different appearance from those of Zygoptera; they have no caudal gills, but breathe by means of tracheal gills developed in the greatly enlarged rectum, which is called the *branchial basket*. Originally these gills were arranged in six longitudinal rows (simplex type), but in the higher forms there are twelve rows (duplex type).

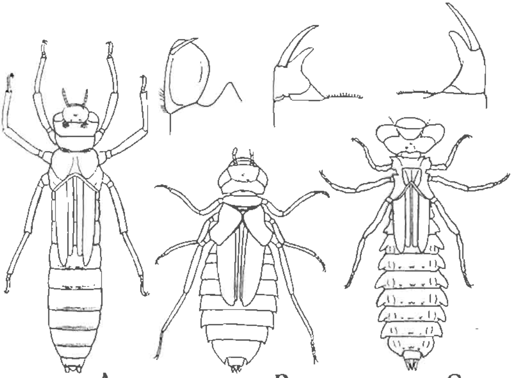
The Suborder is divisible into two well-marked superfamilies, as follows:—

Antenodals of first and second series (i.e., in costal and subcostal spaces) not corresponding, except the two original ones (Ax_1, Ax_2) which are strongly thickened or hypertrophied; triangles variable in shape, but that of forewing never placed markedly transversely to the wing-axis. III. AESCHOIDEA

Antenodals of first and second series entirely, or almost entirely, corresponding; triangles of fore and hind wings markedly dissimilar in form, that of forewing being elongated transversely to the wing-axis and far removed from arculus, while that of hindwing is elongated in the direction of the wing-axis, and is usually placed at or close to the level of the arculus. IV. LIBELLULOIDEA

Superfamily III. AESCHNOIDEA

Four families may be recognized, but only three of these occur in Australia and two in New Zealand; the Cordulegasteridae are absent from both faunas. The rectal gills of the larvae are of various forms, but never of the duplex lamellate type. The three families present may be distinguished as follows:—



A B C

FIG. F20. Larvae of Aeschnoidea (see also fig. F5). A, *Petalura gigantea* Leach (× 1.1), Australia, fam. Petaluridae; B, *Austrogomphus ochraceus* Sel. (× 2.7), Australia, fam. Gomphidae; C, *Austropetalia patricia* Till. (× 1.5), Australia, fam. Aeschnidae, subfam. Petaliinae. Above and somewhat to right of each figure is shown the median and lateral lobe of the mask, enlarged. [*R. J. T. del.*

1. Hindwings without any definitely bounded anal loop; eyes separated; female without ovipositor. 2

Hindwings with a clearly marked, compact, anal loop; eyes generally conjoined; female with well-developed ovipositor. Fam. 12. AESCHNIDAE

2. Very large insects, expanding from 4 to 7 inches, with very elongate, narrow pterostigma; two oblique veins between R_3 and IR_3, triangles of fore and hind wings somewhat dissimilar, subtriangle of forewing large, reticulated; female with ovipositor; inferior appendage of male not bifid. Fam. 10. PETALURIDAE

Smaller insects, expanding from 2 to 4 inches, with shorter and thicker pterostigma; only one oblique vein (O') between R_3 and IR_3; female without ovipositor; male with bifid inferior appendage. Fam. 11. GOMPHIDAE

Family 10. **Petaluridae** [Aus. 3, N.Z. 2]. This family contains only very large dragonflies, whose larvae (fig. F20, A) live in deep burrows in mud or peat. Eyes separate. Anal angle of hindwing always angulated in male; female with ovipositor. In all our species the superior appendages of the male imago are broad and leaf-like; the mask of the larva is short and broad, with prominent triangular median lobe and broad, somewhat concave lateral lobe without setae (fig. F20, A). The Australian species belong to the genus *Petalura*, the commonest being *P. gigantea* Leach of the Blue Mountains of N.S.W.; it is dull brownish in colour, expanding 4½ to 5 inches. *P. pulcherrima* Till. (pl. 4, fig. 1) is a slenderer and more beautifully marked species of about the same size, found in North Queensland. *P. ingentissima* Till., also from North Queensland, is one of the largest dragonflies known, expanding up to 6½ inches. The allied genus *Uropetala* is confined to New Zealand; *U. carovei* Wh. is a large, blackish insect marked with yellow spots, and common in many parts of both islands.

Family 11. **Gomphidae** [Aus. 20, N.Z. 0]. These are graceful, bicolorous species, mostly confined to forest regions; their larvae burrow in the sandy beds of streams, or hide in débris collected in pools or eddies. The imagines can be at once recognized by the separated eyes, the broad occipital shelf, the four- or three-segmented antennae, the narrow abdomen more or less enlarged distally, often with lateral flanges on segs. 7-9, and by the complex appendages of the male; the superior appendages carry projecting hooks or processes which fit on to processes developed on the occiput of the female, and the inferior appendage is deeply bifid so as to appear at first sight to consist of two distinct appendages. Anal angle of hindwing always angulated in male. The females have no ovipositor, and wash out their eggs into running water as they fly up the stream. The prevailing colour is brown or blackish, with bands or rings of yellowish, buff, olive, or green. The larvae (fig. F20, B) have short, four-segmented antennae, often flatly clubbed. The Australian species belong to the genera *Austrogomphus*, *Hemigomphus* and *Ictinus*, the first two being peculiar to Australia, and containing numerous species, most of which are closely similar and only to be distinguished by details of colour-pattern and form of appendages. *Austrogomphus ochraceus* Sel. is one of the commonest species; its larva (fig. F20, B) lives in débris. *A. guérini* Ramb., common in South-eastern Australia, is the only species recorded from Tasmania, and is also the only one of this genus whose larva can exist in still water. *Hemigomphus heteroclitus* Sel. (pl. 5, fig. 1) is a handsome species with large appendages in the male; its larva burrows in sand. *Ictinus australis* Ramb. (pl. 5, fig. 2) is a larger tropical and subtropical species which flies very gracefully over lagoons and billabongs; it has wide flanges on segs. 7-9 and is black and olive-green in colour.

Family 12. **Aeschnidae** [Aus. 31, N.Z. 1]. This family contains the true hawking dragonflies, distinguished by their large size, their usually greatly conjoined eyes, their wings with the triangles closely similar and both elongated in the direction of the wing-axis, and the hindwing with a well-defined, more or less quadrangular anal loop (fig. F18, *al*). R_3 always strongly arched or waved. The males have the anal angle of the hindwing angulated except in the genus *Anax*, in which this angle is rounded. Female always with well-developed ovipositor. The larvae are of very characteristic shape (figs. F5, F20, C), with long, flat mask, having a strong movable hook and a lateral lobe, either of the Gomphid type or else with an end-hook (fig. F5, C, *ch*).

The Petaliinae are a small group of archaic forms in which the triangles are not so elongated as usual in this family, the eyes only just meeting or slightly separated, the inferior appendage of the male longer than the superiors, and the costal margin of the wings marked with a series of brown or ruby-red blotches. They are confined to Australia, Tasmania and Chile. Their larvae cling to the faces of waterfalls, and are shaped so as to resemble a pinnule of

the dead frond of a fern (*cf.* fig. Z51). *Austropetalia patricia* Till. (pl. 11, fig. 2) occurs sparingly on the Blue Mountains.

The subfamily Brachytrinae has its headquarters in Australia, where it is represented by numerous species of *Austroaeschna* and allied genera. The genus *Austroaeschna* contains handsome insects, marked with green, yellow or creamy bands and spots on a dark ground-colour; they occur chiefly on the mountains of Eastern Australia and Tasmania, and most of them fly late in the season (February to May). The dull-coloured *A. parvistigma* Sel. (pl. 4, fig. 2) is one of the commonest. *Austrophlebia costalis* Till. is a magnificent insect expanding 5½ inches, with broad brown bands along the costa of each wing; it flies at a tremendous speed, estimated at nearly sixty miles an hour, along small creeks in the rich scrubs of Queensland and New South Wales. *Telephlebia* is an allied genus with several species marked with broken brown bands along the costa of each wing; the best known species is *T. godeffroyi* Sel. (pl. 4, fig. 3); these insects fly in shady gullies from late afternoon to midnight, and are sometimes taken at light; they devour great numbers of mosquitoes, and are so coloured that they are almost invisible when flying against a dark background.

In the subfamily Aeschninae, Australia possesses two or three species of the tropical genus *Gynacantha* and one of *Austrogynacantha*. *Aeschna brevistyla* Ramb. (pl. 4, fig. 4) is abundant throughout Australia except in the Tropics, and is common in Tasmania; it is also not uncommon in parts of New Zealand, where it is the only known Aeschnid. The genus *Anax* is represented by the very common, brown *Anax papuensis* Burm. (pl. 4, fig. 5), absent from Tasmania, and by two large and handsome tropical species expanding about 5 inches.

Superfamily IV. LIBELLULOIDEA

The members of this group, which marks the highest point of evolution yet reached in the Order, are at once distinguished by the marked differences in the form of the triangles of the fore and hind wings, (figs. F16, F19); the subtriangle is well-developed and often reticulated in the forewing, but is weak or absent in the hind. Eyes nearly always conjoined for a considerable distance. Labium with reduced median lobe and huge lateral lobes without movable hooks. Females without ovipositor. Larvae with broad, spoon-shaped mask (fig. F21), having a short, movable hook and rows of setae on both mentum and lateral lobe; rectal gills always lamellate, arranged in twelve rows (duplex type). There are only two families, which can be separated as follows:—

Triangle of forewing not excessively narrowed; anal border of hindwing angulated in male (except in *Hemicordulia*); eyes with a slight sinuous projection near middle of posterior margin; a keel present on fore tibia of male; auricles present in male (except in *Hemicordulia*).
Fam. 13. CORDULIIDAE

Triangle of forewing usually excessively elongated; anal border of hindwing never angulated; eyes globular; tibial keel and auricles always absent.
Fam. 14. LIBELLULIDAE

Family 13. **Corduliidae** [Aus. 37, N.Z. 4]. Australia is the headquarters of this interesting family and contains 40 per cent. of the known genera for the world. Abdomen subcylindrical or corduliform (i.e., shaped like an Indian club, but slenderer). The subfamily Macromiinae contains large, swift-flying species, superficially resembling Aeschninae; two rare species of *Macromia* occur in North Queensland. The subfamily Syntheminae contains medium-sized dragonflies of slender build and graceful flight, with the basilar space of both wings reticulated (fig. F16). Outside of Australia they are only known from Papua, New Caledonia, and Fiji. The genera *Synthemis*, *Synthemiopsis*, *Eusynthemis* and *Choristhemis* comprise in all about sixteen species, whose headquarters are the mountains of Eastern Australia. *S. eustalacta* Burm. is a handsome insect found on mountain streams; it is dark brown with pale yellow markings. The pinkish-brown *S. macrostigma* Sel. occurs as three distinct subspecies in Western Australia, Eastern Australia and Fiji. *S. regina* Sel. (pl. 5, fig. 3), the finest of our species, black and yellow in colour, is confined to still water in Eastern Australia. *Synthemiopsis gomphomacromioides* Till. (pl. 5, fig. 4) is a rare Tasmanian species. The larvae of this subfamily (fig. F21, A) are peculiar in being very hairy, and in possessing divergent wing-sheaths like those of the larvae of Cordulegasteridae; they live in mud or sand, and can withstand long droughts.

The Idocorduliinae include a number of peculiar genera, mostly monotypic,

and all of them rare; the most beautiful species is the fine black and reddish-brown *Hesperocordulia berthoudi* Till. (pl. 5, fig. 5) from Western Australia. A very peculiar genus, forming a subfamily by itself, is *Cordulephya*, which contains four rather small, slender species with triangles of both wings four-

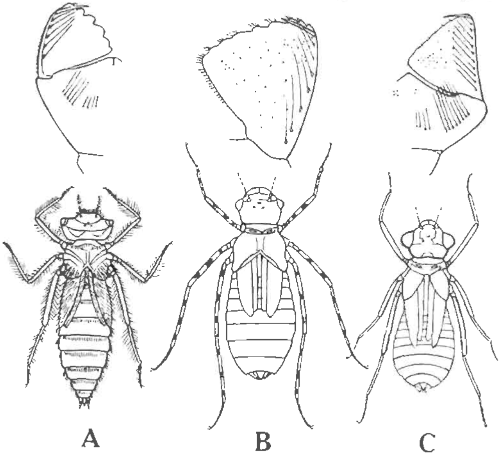


FIG. F21. Larvae of Libelluloidea. A, *Synthemis eustalacta* Burm. (× 2.3), Australia, fam. Corduliidae, subfam. Syntheminae; B, *Hemicordulia tau* Sel. (× 2), Australia, fam. Corduliidae, subfam. Corduliinae; C, *Diplacodes bipunctata* Br. (× 2.7), Australia and N.Z., fam. Libellulidae, subfam. Sympetrinae. Above, left half of mask of A, right lateral lobe of mask of B, and right half of mask of C, all much enlarged. [*R. J. T. del.*

sided, and having the habit of sitting about on rocks and tree-trunks with their wings folded back vertically like those of Zygoptera. *C. pygmaea* Sel. is the best known species; the larger *C. montana* Till. (pl. 5, fig. 6) is found on the Blue Mountains. The larvae have the lateral lobes of the mask deeply cleft.

In the subfamily Corduliinae, the genus *Procordulia* is represented by two Australian and two New Zealand species; of the latter, *P. smithii* Wh. is very common, while the handsomer *P. grayi* Sel. (pl. 2, fig. 4) is much more local. New Zealand also possesses a single rare species of the genus *Somatochlora*, *S. braueri* Sel. The genus *Hemicordulia*, in which the male has rounded hindwings and no auricles, has its headquarters in Australia; *H. tau* Sel., with a black T-mark on its pale yellow frons, is the commonest, and *H. superba* Till. the handsomest species; *H. australiae* Ramb., with metallic green frons, ranges far and wide over Australia, Tasmania, Norfolk, Lord Howe, and Kermadec Islands, and is occasionally taken in New Zealand. The larvae of this subfamily (fig. F21, B) are smooth, with slender legs; the mask has the inner margin of the lateral lobe moderately crenulated.

Family 14. **Libellulidae** [Aus. 39, N.Z. 1]. This is the dominant family of Dragonflies in all tropical and subtropical countries, and is well represented in the warmer parts of Australia, though only two species reach to Tasmania and one to New Zealand. The abdomen is generally depressed and somewhat broadened, and the anal loop of the hindwing is more or less stocking-shaped (except in Tetratheminae). The larvae dwell in water-weeds or on the bottoms of still pools, and have very prominent eyes (fig. F5, D); the mask

resembles that of the Corduliinae, but the inner margin of the lateral lobe is seldom more than very slightly crenulated.

The Tetratheminae contain a few small, archaic forms with black and yellowish pattern and narrow wings; the anal loop is very small or absent, and the triangle of the forewing has its upper side broken, so as to appear quadrangular; species of *Tetrathemis* and *Nannophlebia* are found in the warmer parts of Eastern Australia, the largest being *N. risi* Till. (pl. 5, fig. 7).

In the Libellulinae, Australia has several fine species of *Orthetrum* (fig. F19), the commonest being the pale blue *O. caledonicum* Br., the bright red *O. villosovittatum* Br. (pl. 5, fig. 8) and the brown and straw-coloured *O. sabina* Drury. The tropical genera *Agrionoptera* and *Lathrecista* have narrower wings; *L. asiatica festa* Sel. (pl. 5, fig. 9) is a handsome, red-bodied species. The Brachydiplacinae contain the very small species of *Nannophya* (pl. 5, fig. 10), in which the club-shaped abdomen is tipped with bright red in the male, together with several other less common forms. The Sympetrinae are well represented in Australia and include several very common species of *Diplacodes*. *D. bipunctata* Br., abundant in Australia but absent from Tasmania, is the only Libellulid found in New Zealand; the male is dull red with black spots on abdomen. The darker and almost black-headed *D. melanopsis* Mart. (pl. 4, fig. 6) and the bright red *D. haematodes* Kby. are also common throughout Australia. *Crocothemis nigrifrons* Kby. is a handsome insect of larger size resembling *Orthetrum caledonicum* Br., but with black head. The genus *Neurothemis* contains only tropical species in which the wings of the males are shaded with black or brown, and are very densely reticulated. The allied subfamily Leucorrhiniinae is only represented by the handsome, red and black *Austrothemis nigrescens* Mart. (pl. 4, fig. 7) found chiefly in Tasmania and Western Australia.

The Trameinae contain the most highly evolved of all dragonflies. All the species are tropical or subtropical, but two of them, *Tramea loewii* Br. (pl. 4, fig. 8) and the circumtropical *Pantala flavescens* Fabr., extend as far south as Sydney. In Queensland the graceful dragonflies of the genus *Rhyothemis* may be seen floating about like butterflies and exhibiting their beautifully coloured wings. *Rh. graphiptera* Sel. (pl. 11, fig. 3) occurs as far south as northern N.S.W. *Rh. phyllis chloë* Kby. is common as far south as Brisbane, but the lovely *Rh. resplendens* Sel. (pl. 11, fig. 4) is confined to North Queensland and Papua.

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CHAPTER X

Order ORTHOPTERA

(Cockroaches, Mantids, Phasmids, Locusts, Grasshoppers, Crickets)

THE Order Orthoptera contains the most primitive types of terrestrial winged insects, in which the larval forms closely resemble the imago except for the absence of functional wings, and both larva and imago pursue the same habits of life. Perhaps no Order has suffered so much of late from the vagaries of splitting, Handlirsch even going so far as to subdivide it into two Sub-classes and a number of separate Orders. While admitting that, phylogenetically, the various families included in the Order stand further apart than is the case with the higher Orders, sufficient fundamental agreement remains between them to make it easier to consider them as a single Order than as a group of widely separated Orders, the differences being in no case any greater than those which we can find, for instance, within the Coleoptera or Diptera. True Orthoptera may be always recognized by the typically mandibulate mouth-parts, the presence of short cerci, and the specialized condition of the wings, the forewing being a toughened *tegmen*, while the hind is of large expanse, composed chiefly of an *anal fan* carrying many radiating veins, and except in a few Blattidae, folding up lengthwise only. Owing to the small power of flight possessed by most of these insects, forms with the wings either reduced in size or entirely wanting are common in all the families, but can always be recognized by their close relationship with winged forms.

Characters. H e a d generally oval or transverse; the *antennae* of variable length and segmentation (from 12 to very numerous segments); *compound eyes* placed wide apart, variable in size; *ocelli* present or absent. *Mouth-parts* (fig. A2) typically mandibulate, with all the parts fully formed and suited for biting; *mandibles* strongly toothed; *maxillae* with five-segmented palpi and well developed lacinia and galea; *hypopharynx* a projecting, tongue-like lobe; *labium* divided medially with three-segmented palpi, well developed glossae and paraglossae.

T h o r a x with the *prothorax* usually larger than the other segments (except in Phasmatidae), and often with the pronotum greatly enlarged or lengthened so as to cover the bases of the forewings. *Legs* variable, formed for walking, running, climbing or jumping; in Mantidae the forelegs are raptorial. *Spiracles* two pairs.

W i n g s generally of little use for flight, though some locusts fly for great distances. *Forewing* usually a tegmen of tough,

parchment-like consistency, mostly used to cover the folded *hind-wings*, which are large, delicate, membranous wings consisting of a narrow pre-anal area and a widely expanding *anal fan*: the latter is supported by numerous radiating veins, all convex, and separated by weaker, secondary, concave or furrow veins, so that the wing can be folded up longitudinally like a fan. *Venation*:—*Sc* either simple or with an anterior branch; *R* a strong, straight vein, usually with *Rs* pectinately branched and arising well away from base; *M* and Cu_1 branched; Cu_2

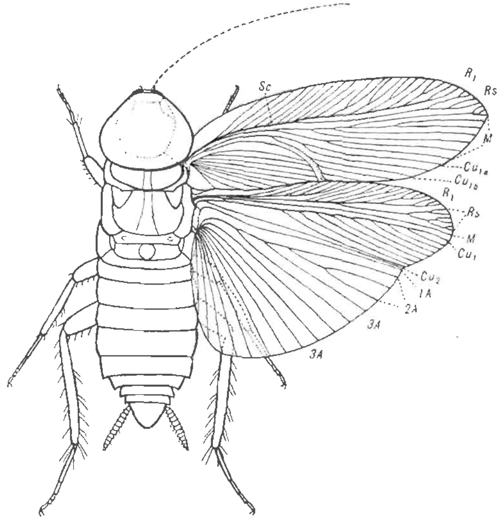


FIG. 61. *Ischnoptera australis* Sauss., male, Australia. Fam. Blattidae, subfam. Pseudomopinae. Lettering as in fig. A8, p. 22. [R. J. T. del.

forming the concave *vena dividens* separating the anal area from the rest of the wing; anal area compact and convex, often with very specialized venation. Hindwing with *Sc*, *R*, *M*, and Cu_1 close together, the branches of all except the last-named much reduced; *1A* running close to Cu_2; radiating veins of anal fan formed from *2A* and *3A*, mostly from the latter; intercalated concave veins of the fan formed by alignment of connecting cross-veins of the original meshwork. *Veinlets* and *cross-veins* usually numerous on all parts of the wings, the former always oblique, the latter irregular and frequently arranged into separate areas of cellules by means of thickened dividing veins.

Researches on the Palaeozoic Order Protorthoptera make it highly probable that the media in this Order really consists of a forked *anterior*

median (*MA*) and a usually simple *posterior median* (*M* of Comstock), the latter being absent in some of the higher types. Pending the completion of this research, we have kept to Comstock's notation in the figures.

Abdomen with ten segments, of which the first is usually reduced in size (elongated in Phasmatidae). *Cerci* present, short, either simple or segmented. *Spiracles* eight pairs, on segs. 1-8. Males with ninth sternite and its gonocoxites generally fused together to form a large, plate-like *hypandrium* (fig. A1, *hy*), divided in Phasmatidae, and nearly always carrying styles; aedeagus frequently asymmetrical, the penis usually large, often bilobed, the two parameres differing greatly from one another in size, shape and position; supra-anal plate usually vestigial or absent (present in Acridioidea); tenth tergite forming a flap which protects the anus from above; paraprocts present, variable. Females with or without a complete ovipositor.

Life History. The *eggs* may be laid in a clump in the ground, or dropped singly, or placed all together in a special receptacle or *ootheca* (figs. G2, B, G5, B). The young hatch out as larvae not unlike the adult in form, but without any wing-rudiments. The habits and food of the young are similar to those of the adult; there are from six to eight instars, the wings appearing as small buds which increase at each succeeding ecdysis, either keeping the same relative positions, as in Blattoidea, Mantoidea and Phasmatoidea, or becoming turned over, when a certain size, so that the hind wing-sheaths cover the fore, as in Acridioidea. Entirely wingless forms, such as the Wetas, never show any signs of wing-rudiments at any stage, and are therefore only to be distinguished from true Apterygota by their general morphology.

Distribution. The Order is well represented both in Australia and New Zealand, more than eleven hundred species being known from the former and less than a hundred from the latter country. Australia is rich in all the principal families, the Acridiidae (354), the Blattidae (300) and the Tettigoniidae (193) being especially abundant. New Zealand has few Blattidae and only a single species of Mantidae, probably introduced from Australia, but is rich in wingless forms of Phasmatids, and more especially in those remarkably specialized, wingless forms of Tettigoniidae known as Wetas and Cave-locusts.

Economics. The Order being chiefly vegetarian, with some omnivorous forms like the Cockroaches, must be classed as on the whole *injurious to mankind*. Cockroaches are well-known pests of houses, stores and ships, but the native species seldom do any harm. Phasmatids sometimes occur so abundantly in Australia that they defoliate large areas of Eucalyptus forest, but the New Zealand species have never been known to do any damage. Certain species of Acridiidae in Australia, as in other dry countries, at times assume the proportions of a veritable plague, sweeping over the pastures of the dry interior and eating every blade of grass. King Crickets and Wetas are formidable insects which can inflict a nasty bite if handled carelessly. Mole crickets often damage potato crops. The only beneficial group is the Mantidae, whose voracious onslaught on flies and other noxious insects should entitle them to protection everywhere.

Fossil History. Almost the earliest known record of the Class Insecta in Europe shows the Cockroaches already in the

ascendant, forming more than 90 per cent. of the insect fauna of some of the Upper Carboniferous beds of Western Europe. From that pre-eminence, which was lost during the Permian, they have gradually descended, until, at the present day, they form less than 1 per cent. of the World's insect fauna. In Australia they do not appear until the Upper Trias, being later arrivals than the Mecoptera, Planipennia and Homoptera. True Acridioidea of the family Elcanidae have been found in the passage beds between Upper Permian and Trias at Bulli, N.S.W., and early types related to Mantidae and Tettigoniidae in the Upper Trias of Ipswich, Q. These co-existed with a very few primitive forms of large size which are best referred to the extinct Order Protorthoptera.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order ORTHOPTERA 1114 (80)

I. BLATTOIDEA 300 (6)
  1. Blattidae 300 (6)

II. MANTOIDEA 81 (1)
  2. Mantidae 81 (1)

[GRYLLOBLATTOIDEA]
  [Grylloblattidae]

III. PHASMATOIDEA 112 (14)
  3. Phasmatidae 112 (14)

IV. ACRIDIOIDEA 621 (59)
  4. Tettigoniidae 193 (40)
  5. Gryllidae 50 (2)
  6. Gryllotalpidae 6 (1)
  7. Acridiidae 354 (16)
  8. Tettigidae 18 (0)

The Order is divided into five very distinct superfamilies, each of which may be considered as a distinct Suborder if preferred. The Grylloblattoidea are only represented by a single very isolated family, Grylloblattidae, with a single species, *Grylloblatta campodeiformis* E. Walker, a very rare insect found near the top of Sulphur Mountain, near Banff, British Columbia. They are included in the following Key, as it seems just possible that some similar, archaic type of Orthopterous insect might one day be discovered on the mountains of Australia or New Zealand:—

1. All three pairs of legs similar, formed for walking, running or climbing. 2
   The three pairs of legs dissimilar (either the fore legs specialized for seizing prey, or the hind legs for jumping). 4
2. Prothorax larger than the other thoracic segments; coxae large, elongated, placed close together; cerci segmented. 3
   Prothorax very small, much shorter than the elongated mesothorax; legs formed for climbing, with small coxae placed wide apart; cerci simple. III. PHASMATOIDEA
3. Head exserted in front of the trapezoidal pronotum; females with well developed ovipositor. [GRYLLOBLATTOIDEA]
   Head more or less hidden beneath the broad, shield-like pronotum; female without ovipositor. I. BLATTOIDEA
4. Fore legs highly specialized for seizing prey, the femur and tibia armed, the tibia folding back upon the femur. II. MANTOIDEA
   Hind legs highly specialized for jumping, much larger than middle or fore legs, the hind femora greatly enlarged. IV. ACRIDIOIDEA

Several alternative classifications exist. The Blattoidea are called by some authors Cursoria; the Mantoidea, Raptoria; the Phasmatoidea, Gressoria; and the Acridioidea, Saltatoria; each of these being considered a Suborder. The Blattoidea and Mantoidea together are sometimes termed Dictyoptera or Oothecaria, the former name alluding to the reticulate wings (a character shared by other members of the Order and many insects outside of it), the latter to the habit of placing the eggs in a special receptacle. Some authors even go so far as to consider each of the five main groups as a separate Order.

Superfamily 1. BLATTOIDEA

Family 1. **Blattidae** (Cockroaches). [Aus. 300, N.Z. 6]. Broad, flattened insects capable of running rapidly; ocelli replaced by a pair of transparent, oval spots without lenses, known as *fenestrae;* pronotum large, shield-like, usually covering the head in front and bases of the tegmina behind. Tegmen of a more or less broadly oval shape, the membrane toughened, the venation very variable, but usually dense; *Sc* much shortened, R_1 a long vein with many anterior branches pectinately arranged (fig. G1), *Rs* either arising far from base or absent, never strongly branched; anal area forming a convex, cultriform clavus, with Cu_2 in the anal furrow. The left tegmen folds over the right.

Though the fossil record shows that Australia was a comparatively late refuge for this once dominant group, the number of species found there at present is very large. About 60 per cent. of the males and 70 per cent. of the females of the known Australian species are either wingless or have reduced, non-functional wings, this condition being correlated with the gradual adoption of the mode of living in all kinds of restricted habitats, such as under logs in the forest, or in burrows. Most of the New Zealand species are entirely wingless; they belong to the subfamily Blattinae.

The Blattinae (Periplanetinae) are probably the most primitive subfamily; they have the femora armed beneath with spines, and the subgenital lamina of the female is bivalvular in form. *Methana* is a primitive, fully winged Australian genus; *M. marginalis* Sauss. (pl. 7, fig. 2) is a handsome, dark brown species with sides of pronotum and costal border of tegmina pale straw-colour. Numerous wingless species of this subfamily occur in Australia, the best known genera being *Platyzosteria*, *Polyzosteria*, *Cutilia*, *Zonioploca*, *Cosmozosteria*, and *Anamesia*. Most of the species are very broad, ugly insects, and not a few emit a more or less unpleasant odour when handled. An exception is the handsome *Polyzosteria mitchelli* Angas (pl. 6, fig. 1) found in South and Western Australia. The common "Maori Bug" of New Zealand is *Platyzosteria novae-seelandiae* Brunn., a black, evil-smelling insect. Another common bush cockroach in New Zealand is *Cutilia sedilloti* Bol. (pl. 7, fig. 1), dark brown and yellowish in colour.

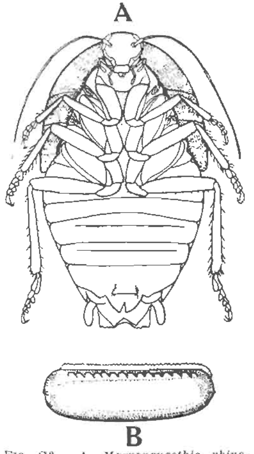


FIG. G2. A, *Macropanesthia rhinoceros* Sauss., female, Australia. Fam. Blattidae, subfam. Panesthiinae. Ventral view. The shaded portion represents the pronotum. Length 45 mm.; B, Egg-capsule of same. Length 17 mm. [*A. Tonnoir del.*

The Epilamprinae are a smaller subfamily, of which the best known genus in Australia is *Calolampra*. *C. irrorata* Fabr. (pl. 7, figs. 5, 6) shows great sexual dimorphism; the male is a speckled, dull brownish insect with elongated tegmina, but the female is short and very broad behind, tapering forwards to an almost triangular pronotum; it has short, lobe-like vestiges of tegmina, but no hindwings.

The Pseudomopinae are represented in Australia by species of *Ischnoptera* and *Ellipsidion*, as well as by the introduced genera *Blattella* and *Supella*. *Ischnoptera australis* Sauss. (fig. G1) is a common, rich brown species. The genus *Ellipsidion* contains broadly rounded cockroaches, elegantly marked in orange-brown and black.

The Ectobiinae include the well known genus *Escala*, with winged males and wingless females. *E. circumducta* Walk. is a common, small, orange-brown species.

The above four subfamilies all have the femora armed with spines. In

PLATE 6

AUSTRALIAN ORTHOPTERA, ISOPTERA AND HEMIPTERA

All figures natural size, except fig. 4

Order ORTHOPTERA

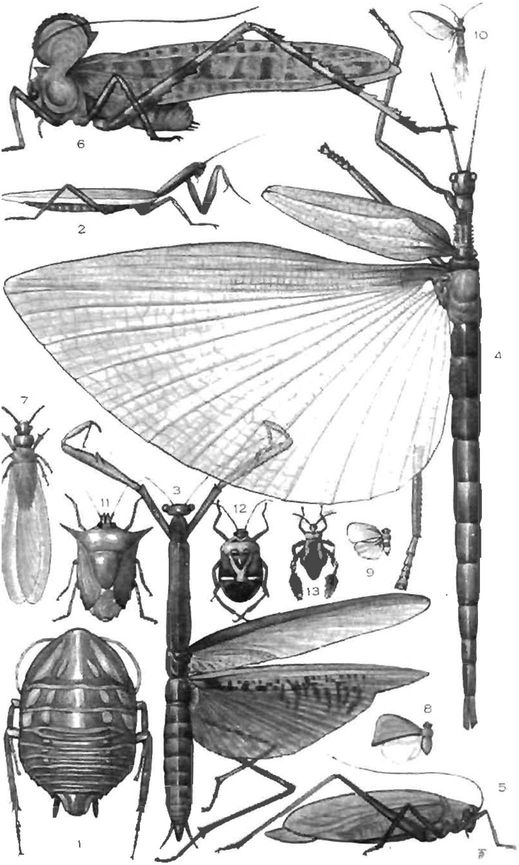
1. *Polyzosteria mitchelli* Angas (Fam. BLATTIDAE).
2. *Orthodera ministralis* Fabr. (Fam. MANTIDAE).
3. *Tenodera australasiae* Leach (Fam. MANTIDAE).
4. *Podacanthus typhon* McCoy (Fam. PHASMATIDAE) (x ⅔).
5. *Caedicia olivacea* Brunn. (Fam. TETTIGONIIDAE).
6. *Alectoria superba* Brunn. (Fam. TETTIGONIIDAE).

Order ISOPTERA

7. *Mastotermes darwiniensis* Frogg. (Fam. MASTOTERMITIDAE).

Order HEMIPTERA

8. *Siphanta acuta* Walk. (Fam. FLATIDAE).
9. *Sephena cinerea* Kirk. (Fam. FLATIDAE).
10. *Callipappus australis* Mask. (Fam. COCCIDAE).
11. *Biprorulus bibax* Bred. (Fam. PENTATOMIDAE).
12. *Commius elegans* Don. (Fam. PENTATOMIDAE).
13. *Ptilocnemus femoratus* Horv. (Fam. REDUVIIDAE).



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AUSTRALIAN ORTHOPTERA, ISOPTERA AND HEMIPTERA

the succeeding groups, the femora are unarmed, except that, in the Panesthiinae, there are often one or two spines on the fore femora only. In this group, the Australian species of the genus *Panesthia* live in burrows in soil in strict family communities, each of which consists of an adult male, a viviparous female, and from ten to twenty of their larval progeny in various stages of growth. Soon after reaching maturity, the adults bite off their own tegmina and wings, these organs being inconvenient for inhabiting the burrows.

The huge, solitary *Macropanesthia rhinoceros* Sauss. (fig. G2, A) is the largest of all Australian cockroaches; the female measures up to two inches or more in length, and is often met with in the bush carrying its large, portmanteau-shaped egg-capsule (fig. G2, B).

The peculiar Australian genus *Oniscosoma* belongs to the subfamily Panchlorinae, having a pad or arolium between the tarsal claws. *O. granicollis* Sauss. (pl. 7, figs. 3, 4) has a fully-winged male of graceful shape and dull, dark brown colour, but the female is a curious wingless object, often found motionless under bark, and not unlike a woodlouse in appearance.

The Oxyhaloinae are a very highly specialized group having the arolium present and the hindwings with a produced and specialized apical portion, which is folded back in repose (fig. G3). *Diploptera dytiscoides* Serv. (fig. G3), originally described from "New Holland" but not since found in Australia,

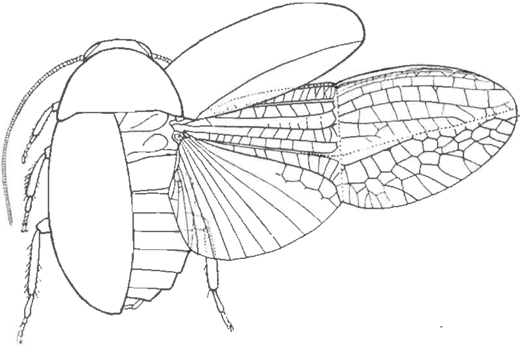

FIG. G3. *Diploptera dytiscoides* Serv., Northern Australia (?) to Hawaii. Dorsal view, with right tegmen and wing expanded. Fam. Blattidae, subfam. Oxyhaloinae. Length of body 13.5 mm. [*A. Tonnoir del.*

occurs throughout the Pacific Islands as far as Hawaii. It is a blackish insect, closely resembling a waterbeetle in appearance. In folding the wings, the apical portion folds first along the transverse dotted line shown in fig. G3, and then along the longitudinal dotted line, while the anal fan folds up in the usual manner; finally, the hard, elytron-like tegmen, which is devoid of venation, folds back automatically into position, and completes the complicated folding of the hindwing by pressing it back into position above the abdomen.

As regards introduced species, both *Periplaneta americana* L. and *P. australasiae* Fabr. are quite common in Australia, being well known pests of bakehouses and ships. The statement that the former has gradually supplanted the latter is incorrect, neither species being really native to Australia. The smaller *Blattella germanica* L. is abundant in houses both in Australia and New Zealand.

Superfamily II. MANTOIDEA.

Family 2. **Mantidae** [Aus. 81, O.Z. 1]. The Mantidae or Soothsayers are remarkable for their raptorial forelegs, placed on an elongated prothorax (fig. A1); these legs have a very strong, elongated coxa, while the femur and

Plate 7

ORTHOPTERA AND DERMAPTERA

All figures natural size, except figs. 7 and 8

Order ORTHOPTERA

1. *Cutilia sedilloti* Bol. (Fam. Blattidae), male, N.Z.
2. *Methana marginalis* Sauss. (Fam. Blattidae), male.
3. *Oniscosoma granicollis* Sauss. (Fam. Blattidae), male.
4. *Oniscosoma granicollis* Sauss. (Fam. Blattidae), female.
5. *Calolampra irrorata* Fabr. (Fam. Blattidae), male.
6. *Calolampra irrorata* Fabr. (Fam. Blattidae), female.
7. *Acrophylla tessellata* Curt. (Fam. Phasmatidae), female (x [illegible]).*
8. *Argosarchus horridus* Wh. (Fam. Phasmatidae), female (x [illegible]), N.Z.
9. *Acridopeza reticulata* Guer. (Fam. Tettigoniidae), female.
10. *Gryllus servillei* Sauss. (Fam. Gryllidae), female, Aus. and N.Z.
11. *Gryllotalpa coarctata* Walk. (Fam. Gryllotalpidae).
12. *Cylindracheta kochi* Sauss. (Fam. Gryllotalpidae).
13. *Goniaea australasiae* Leach (Fam. Acridiidae).
14. *Coryphistes ruricola* Burm. (Fam. Acridiidae).
15. *Paprides nitidus* Hutt. (Fam. Acridiidae), N.Z.

Order DERMAPTERA

16. *Anisolabis littorea* Wh. (Fam. Labiduridae), male, N.Z.
17. *Apachyus australiae* Till. (Fam. Labiduridae), n.sp., male.

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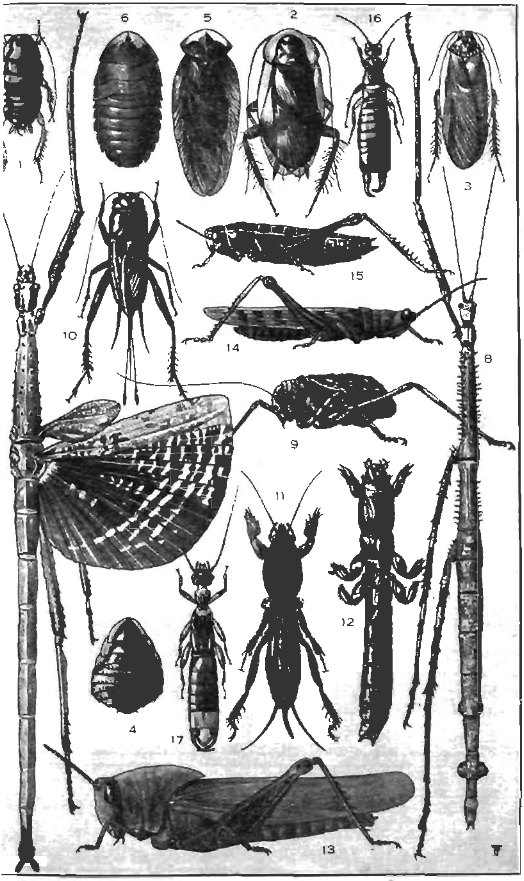
*The pale markings on the lower half of the hindwing of this insect sh be less obliquely placed than in the figure.



Tillyard del.

ORTHOPTERA AND DERMAPTERA

tibia are specialized for seizing the prey; the tarsi are slender, unarmed, and apparently in many cases more or less useless. Three ocelli are present. Most of the species have the forewings only partially tegminized, with venation well developed; *Sc* and R_1 are normal, but *Rs* is always short, arising towards the apex of the wing. The eggs are laid in a papery capsule attached to fixed objects (fig. G5), not carried about as in the Blattidae, and formed of a frothy substance exuded by the female. The young of the genus *Orthodera* hatch out as well-formed larvae about half-an-inch in length, and at once begin their predatory existence.

This family is chiefly a tropical one, and very few of the Australian species are at all common. The best known is the bright green *Orthodera ministralis* Fabr. (fig. G1 and pl. 6, fig. 2) common also in New Zealand, where it appears to have arrived with the earliest white settlers. The handsome, elongated *Archimantis latistylus* Fabr., of a pinkish-brown colour, is also frequently met with in the bush around Sydney; the males have long wings, but those of the female are only half as long. An even larger species, *A. monstrosa* Mason, with spiny prothorax, is found in Northern Australia. *Tenodera australasiae* Leach (pl. 6, fig. 3) is a long, slender species not uncommon in the bush around Sydney; the tegmina are bordered anteriorly with green and pink, and the hindwings are partly pink and partly mottled brownish-black.

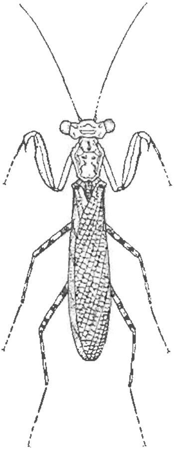


Fig. G4. *Phthersigena conspersa* Stal., female, Australia. Fam. Mantidae, subfam. Perlamantinae. Length 22 mm. [*R. J. T. del.*

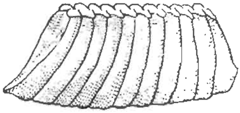


Fig. G5. Egg-capsule of *Orthodera ministralis* Fab. Length 12 mm. [*P. Tillyard del.*

The small, bark-haunting Mantids of the subfamily Perlamantinae are well represented in Australia by seven species placed in five genera. *Paraxypilus* and *Myrmecomantis* have wingless females, superficially resembling large ants. *Phthersigena conspersa* Stal. (fig. G4) is winged in both sexes. All the species are dull brownish or blackish, less than an inch in length.

Superfamily III. PHASMATOIDEA.

Family 3. **Phasmatidae** (Stick and Leaf-Insects). [Aus. 112, N.Z. 14]. Insects of large to very large size, of long, slender shape, with small oval head, small eyes, three ocelli, small and very short prothorax, greatly elongated mesothorax, abdomen with the first segment closely fused with the metathorax, and unsegmented cerci. The three pairs of legs are placed far apart, each near the posterior end of its corresponding thoracic segment. The tegmina are

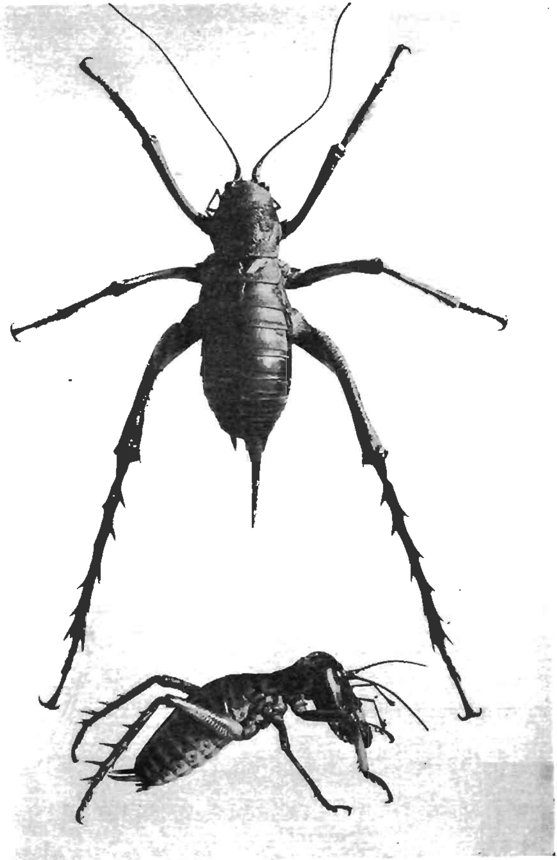
PLATE 8

NEW ZEALAND ORTHOPTERA

Both figures only four-fifths natural size

(Above). *Deinacrida heteracantha* Wh. (Fam. TETTIGONIIDAE), female. The Giant Weta. (Unique female, from Buller Collection, Dominion Museum, Wellington.)

(Below). *Hemideina megacephala* Buller (Fam. TETTIGONIIDAE), male. The Common Tree Weta.



W. C. Davies photo.

NEW ZEALAND ORTHOPTERA

always greatly reduced in size; the hindwings have a great expanse, and the part anterior to the anal fan is tegminous in consistency. Females without ovipositor, but with a shovel-like projection below segment 8. Eggs moulded singly by the female in hard capsules, often beautifully shaped, and dropped at random upon the ground. Females usually much larger than the males. The New Zealand species are all wingless.

Some of the largest Phasmatids in the world are found in Australia, especially in North Queensland. The female of *Palophus titan* Sjost. is ten inches in length and has an expanse of wing about the same. The genus *Acrophylla* contains a number of very fine, dark coloured species in which the females, measuring up to eight inches or more in length, have short and very broad wings, while the slenderer males, little more than half the length of their mates, have fully developed wings of much larger size. *A. tessellata* Curt. (pl. 7, fig. 7) is brownish, with chocolate-coloured wings marked with a tessellated pattern of whitish patches. The genus *Podacanthus* contains several very handsome species with bright coloration. *P. wilkinsoni* Macl., expanding 4 to 5 inches, has green and brown tegmina, the hindwings being green anteriorly with the anal fan a beautiful rose-pink; it is sometimes so abundant that it causes serious damage to Eucalyptus forests by defoliating the trees. The somewhat similarly coloured but much larger *P. typhon* McCoy (pl. 6, fig. 4), expanding up to 7 inches, is also widely spread in Eastern Australia. *Tropidoderus* contains large species with the thorax shorter and the body broader than usual; the middle and hind legs have the femora expanded into a leaf-like form; *T. rhodomus* McCoy expands up to 9 inches. The most remarkable species of all is *Extatosoma tiaratum* Macl. (fig. G6), 4 to 5 inches long, of rather stout build, having the abdomen fringed with spiny processes and the legs irregularly dilated, so that the whole insect closely resembles a portion of a spiny-leaved plant; the male has ample wings, but those of the female are greatly reduced and functionless.

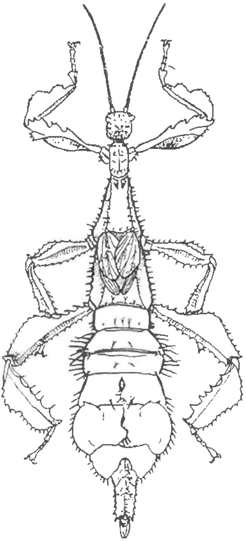


FIG. G6. *Extatosoma tiaratum* Macl., female. Australia. Fam. Phasmatidae. Length 4½ inches. [*P. Tillyard del.*

The New Zealand species all belong to six genera of the subfamily Clitumninae, viz. *Pachymorpha*, *Clitarchus*, *Micrarchus*, *Mimarchus*, *Acanthoderus* and *Argosarchus*. *Acanthoderus prasinus* Wwd. is the common, slender, green stick-insect, the female measuring about 3½ inches in length. *Pachymorpha hystriculea* Wwd. is a spiny, dark brownish species measuring 1½ to 3 inches in length; the female closely resembles a thorny twig. *Argosarchus* contains two much larger species with spiny thorax; the female of *A. horridus* Wh. (pl. 7, fig. 8) is 5 to 6 inches long and of a dull brown colour with pale, lichen-like patches.

Superfamily IV. ACRIDIOIDEA.

This group, which contains the Locusts, Grasshoppers and Crickets, is divisible into five well-marked families, in all of which the larval hind wing-sheath comes to overlie the fore at the fourth instar. The following Key will distinguish them:—

1.	Antennae short; ovipositor of female reduced or absent.	2
	Antennae elongated; ovipositor large and fully developed.	4

2\. Burrowing insects, with huge oval prothorax, strongly dilated burrowing forelegs, and antennae composed of numerous very short segments. Fam. 6. GRYLLOTALPIDAE

Insects with normal forelegs; tarsi 3-segmented; antennae with much fewer segments, each longer than wide 3

3\. Pronotum not extending far back so as to cover the abdomen from above; tegmina frequently present. Fam. 7. ACRIDIDAE

Pronotum extending back so as cover abdomen; tegmina reduced to a minute, scale-like flap. Fam. 8. TETTIGIDAE

4\. Tarsi 4-segmented; tegmina, when present, held roof-wise over the body. Fam. 4. TETTIGONIIDAE

Tarsi 3-segmented; tegmina when present held with the anal area flat upon the body, the rest folded vertically downwards at sides of same. Fam. 5. GRYLLIDAE

Family 4. **Tettigoniidae*** (Long-horned Locusts, Cave Locusts and Wetas). [Aus. 193, N.Z. 40]. In this family the wings are held roof-wise over the body; the antennae are very long and slender, composed of from 50 to over 500 segments; the ocelli are frequently absent, or only one present; the tarsi are 4-segmented; the female has a well developed ovipositor. Ears are usually present on the fore tibiae, below the knee. In the males, the sound is produced by means of a file on the clavus of the left tegmen working under a sharp rasping edge on the right tegmen.

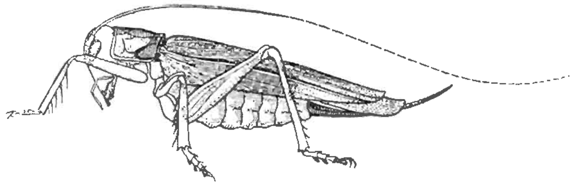


FIG. 67. *Paragryllacris combusta* Germ., female, Australia. Fam. Tettigoniidae, subfam. Gryllacrinae. Apical portion of antenna omitted. Length to end of ovipositor 54 mm. [*P. Tillyard del.*

This family is well represented in both countries. Many rare species are found in the tropical parts and dry interior of Australia, while in New Zealand Cave Locusts and Wetas abound. The primitive subfamily Phaneropterinae is exceptionally well represented in Australia by more than sixty species, one of the commonest being the Large Speckled Grasshopper, *Ephippitytha 32-guttata* Serv., found in the coastal districts. The handsome Crested Grasshopper, *Alectoria superba* Brunn. (pl. 6, fig. 6) lives in the dry inland districts. The Mountain Grasshopper, *Acridopeza reticulata* Guer. (pl. 7, fig. 9) has a fully winged male of a dark brown colour, but the female is a short, stout insect with shortened, crumpled tegmina and no wings; the abdomen beneath the tegmina is brightly marked with red, white and blue. *Caedicia olivacea* Brunn. (pl. 6, fig. 5) is a handsome green species found both in Australia and New Zealand.

The closely allied subfamilies Xiphidiinae, Agroeciinae and Conocephalinae are fairly well represented in Australia, but the only New Zealand species is *Xiphidium semivittatum* Walk. which also occurs, along with other species of the same genus, in Australia. The peculiar Prochilinae are represented in Australia by *Phasmodes ranatriformis* Wwd., an elongated, wingless species closely resembling a Phasmatid, and by the allied *Zaprochilus australis* Brullé which has narrow wings.

The Gryllacrinae, absent from New Zealand, are well represented by more than fifty species in Australia, chiefly belonging to the genus *Paragryllacris*;

*Originally Locustidae, but the type of the genus *Locusta* is an Acridiid! Kirby renamed the family Phasgonuridae; but *Phasgonura* Stephens, 1835, is a synonym of *Tettigonia* L., the type of both genera being *viridissima* L.

one of the commonest species is *P. combusta* Germ. (fig. G7), a large brown species with very long antennae; it lives in holes in trees and between the leaf-sheaths of certain plants.

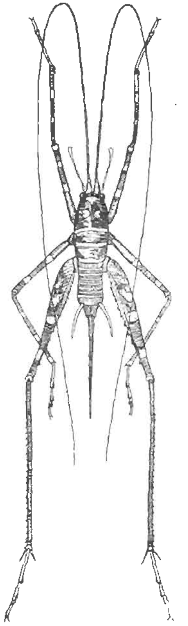


FIG. G8. *Pachyrhamma fascifer* Walk., female, New Zealand. Fam. Tettigoniidae, subfam. Rhaphidophorinae. Length of body, including ovipositor, 42 mm. Antennae in nature held straight out in front of head (curved back in drawing to save space). [*P. Tillyard del.*

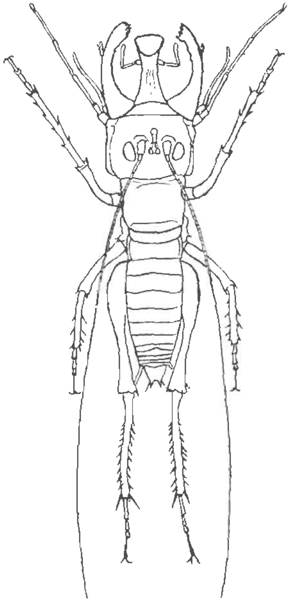


FIG. G9. *Anostostoma australasiae* Gray, the Large Australian King Cricket, male. Fam. Tettigoniidae, subfam. Stenopelmatinae. Length 3 inches. [*P. Tillyard del.*

The subfamily Rhaphidophorinae contains the Cave Locusts, also called Cave Wetas in New Zealand, where they are much more abundant than in Australia. These extraordinary insects have neither ears nor sound-producing apparatus, and are entirely wingless; they have very short bodies and excessively long legs and antennae. One of the commonest New Zealand species is *Pachyrhamma fascifer* Walk. (fig. G8), in which both sexes measure about eight or nine inches from tip of antenna to end of hind leg; it occurs abundantly in an old tunnel near Wellington. *P. acanthocera* Milligan is a much larger species, recently discovered near Auckland, the total length being from 12 to 14 inches and the antennae having more than 550 segments, some of them armed with small spines.

The Stenopelmatinae include the true Wetas of New Zealand and the King Crickets of Australia; they are characterized by their stout, heavy build, complete absence of wings, strongly ridged and spiny tibiae, and the generally fierce aspect and huge jaws of the males. The commonest species is *Hemideina megacephala* Buller (pl. 8, fig. 2), found all over New Zealand in rotten logs, old trees and under loose bark. It is a shiny, dark brown insect, capable of making a short grating sound by scraping the tuberculated hind femora against a small series of ridges on the third abdominal segment. The male has an enormous head with huge jaws. *Onosandrus* is a genus which contains smaller Wetas, living in closed burrows in the ground; one species has a peculiar forked appendage on the sixth abdominal sternite. The largest of the New Zealand Wetas are *Deinacrida heteracantha* Wh. (pl. 8, fig. 1) and *D. rugosa* Buller, dull brownish insects of very clumsy build, found hiding beneath rocks or browsing on grass at night. *D. heteracantha* has a body 4 inches long and long spiny legs; it is practically extinct. *D. rugosa* is a somewhat smaller insect with shorter legs; it is still abundant on Stephens Island.

The King Crickets of Australia belong to the genus *Anostostoma*, related to *Hemideina*. *A. australasiae* Gray (fig. G9), the Large King Cricket, is a huge brown insect, found in Queensland and New South Wales; the male has an enormous head, with large, projecting mandibles.

Family 5. **Gryllidae** (Crickets). [Aus. 50, N.Z. 2]. This family is a specialized offshoot of the Tettigoniidae, and differs from them in having the clavi of the tegmina folded flatly upon the body, while the rest of the wing lies vertically against its sides. Tarsi 3-segmented. The ears are placed as in the Tettigoniidae, and the song of the males is produced in the same way, but each tegmen has a well-developed file formed of short cross-ridges. The Common Field Cricket of Australia is *Gryllus servillei* Sauss. (pl. 7, fig. 10); this species has been introduced into New Zealand. Small crickets of the genera *Nemobius* and *Lissotrachelus* are black in colour; *L. maoricus* Walk. is not uncommon in New Zealand.

Family 6. **Gryllotalpidae** (Mole-Crickets). [Aus. 6, N.Z. 1]. These insects can be at once distinguished from the Gryllidae by the shortened antennae, formed of numerous, short, ring-like segments, the huge, convexly oval prothorax, the burrowing forelegs, and the absence of sound-producing organs and ears. The common Australian Mole-Cricket is *Gryllotalpa coarctata* Walk. (pl. 7, fig. 11). The closely allied New Zealand species, not yet described, is quite wingless. These insects have the forelegs broadly flattened, the first segment of the tarsus carrying sharp teeth and a cultriform blade for digging. Both species are dark brown to black in colour, not so large as the European Mole Cricket. The most interesting of the Australian species belong to the genus *Cylindracheta*, slender, elongated crickets which burrow in the stems of plants; *C. kochi* Sauss. (pl. 7, fig. 12) occurs in Western Australia.

Family 7. **Acridiidae** (Short-horned Grasshoppers and Locusts). [Aus. 354, N.Z. 16]. Wings held roof-wise over the body. Antennae short, somewhat thickened or slightly flattened, with less than 30 segments; ocelli present; tarsi

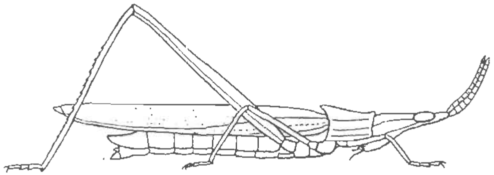


FIG. G10. *Acrida turrita* L., the Long-nosed Locust, Australia. Fam Acridiidae, subfam. Tryxalinae. [*R. J. T. del.*

3-segmented; ears placed on the sides of the first abdominal segment; sound produced in the males by rubbing the ridged hind femur against the sharp edge of a projecting vein on the tegmen. Females with ovipositor reduced. This family is exceedingly abundant all over Australia, but few species are known from New Zealand, mostly belonging to the subfamily Acridiinae.

The subfamily *Tryxalinae* contains species in which the vertex is produced forward like a snout. Nearly 40 species are known in Australia, but none in New Zealand. *Acrida turrita* L. (fig. G10) is the common Long-nosed Locust found on open grass-lands; it is a handsome insect, varying from bright green to pink in colour. The plague locusts of the dry interior belong to the genus *Chortoicetes* and *Calataria*, the worst species being *Ch. pusilla* Walk. and *C. terminifera* Walk. *Froggattina* australis* Walk., the Rose-winged Locust, is a small species with a very shrill note.

In the Oedipodinae are included about 30 Australian species, of which the best known are the three species of *Locusta*. The common *L. danica* L. and the rarer *L. migratoroides* Reich. both occur also in New Zealand, but *L. australis* Brunn. is confined to Australia and Fiji. *Oedaleus senegalensis* Krauss, occurs in Africa and Australia.

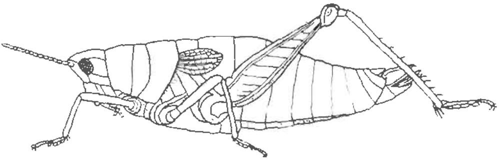


FIG. G11. *Monistria conspersa* Stal., female, Australia. Fam. Acrididae, subfam. Pyrgomorphinae. Length 37 mm. Colour-pattern omitted. [*R. J. T. del.*

The Pyrgomorphinae contain about 30 Australian species, mostly flightless forms belonging to the genus *Monistria*. *M. conspersa* Stal. (fig. G11) is a fine insect of a purplish brown colour, mottled all over with yellow spots, frequently found on the highlands of New South Wales and Victoria.

The Acridiinae contain the great majority of the species. *Acridium guttulosum* Walk. is the large striped locust of the Eastern coast; it measures nearly 3 inches in length. The Ridge-backed Locusts, of which there are nearly 30 species known, belong to the genus *Goniaea*. *G. australasiae* Leach (pl. 7, fig. 13), the best known species, is a large, handsome insect of a uniform fawn colour, common around Sydney. The genus *Coryphistes* contains nine species of speckled grey or fuscous locusts, which rest on tree-trunks and are very difficult to detect; the best known species is *C. ruricola* Burm. (pl. 7, fig. 14). Another common species is the Red-legged Locust, *Cirphula pyrrhocnemis* Stal. Amongst the many species found in the dry interior, we may mention the Crested Locusts, *Ecphantus quadrilobus* Stal. and *E. cristatus* Tepper, and the Spotted Locust, *Stropis maculosa* Stal.

The New Zealand species of Acridiinae are placed in five genera, *Phaulacridium*, *Trigonisa*, *Paprides*, *Sigaus* and *Brachaspis*, of which only the first two are also found in Australia. *Phaulacridium marginale* Walk. is the common

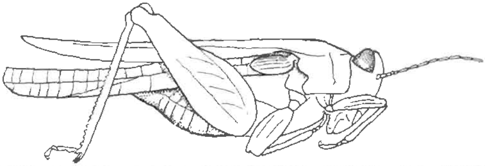


FIG. G12. *Paratettix* sp. indet., Mount Kosciusko, Australia. Fam. Tettigidae. Length 11 mm. [*A. Tonnoir del.*

dull brownish or yellowish grasshopper of rather small size; only about one per cent. of the males are ever fully winged, the females never. *Brachaspis* contains rather stoutly built, dull-coloured, flightless grasshoppers found on

**Froggattina*, new name for *Froggattia* Bol., 1909, preoccupied by *Froggattia* Horv., 1902, see p. 152.

mountains; the largest is *B. collinus* Hutt., dull greyish brown, the female measuring up to 45 mm. in length. *Paprides nitidus* Hutt. (pl. 7, fig. 15) is a handsome mountain species of slenderer build and shining green coloration, with a yellowish stripe on either side of the pronotum passing along the costa of the very short segmen, and the hind femora entirely bright red. *Trigoniza campestris* Hutt. is the large green grasshopper of the Canterbury Plains; the head is narrower than in *Paprides* and the hind femora are only partially reddened.

Family 8. **Tettigidae** (Pygmy Locusts). [Aus. 18, N.Z. 0]. These bizarre little locusts are a specialized offshoot from the last family; the tegmina are reduced to minute scales, and the pronotum extends backwards so as to cover the whole body. The hindwings are often present, and are folded so as to appear almost linear. The family is not known from New Zealand. Most of the Australian species belong to the genus *Paratettix* (fig. G12). They are to be found in moist, mossy places, and sometimes even under water in still pools. In the dry interior there are some exceedingly bizarre forms, not yet described. Most of the species are about half-an-inch in length, and individuals vary greatly in colour.

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See also *Genera Insectorum*; "Acridiidae", fasc. 48 (J. L. Hancock), 90, 170 (I. Bolivar); "Blattidae" fasc., 55, 73, 74, 101, 109 (R. Shelford); "Mantidae", fasc. 119 (J. A. G. Rehn), 144, 177 (E. Giglio-Tos); "Tettigoniidae", fasc. 72, 120, 138, 140, 167, 168, 171 (A. N. Caudell), 131, 135, 139, 141 (H. Karny).

CHAPTER XI

Order ISOPTERA

(Termites, White Ants)

THE insects forming this Order, though popularly known as "White Ants", are not related to the true ants in any way, and only resemble them in their incessant industry and in their highly evolved social state. They are best regarded as a highly specialized offshoot of the original stem of the Orthoptera, and are rather closely related to the Cockroaches; in fact, they may well have been derived from some ancient form of Blattoid ancestor which took to living in communities under logs. They may be distinguished at once from true Orthoptera by the presence of social castes (workers, soldiers and winged individuals) living together in large nests or *termitaria*, and by the form of the wings; with one notable exception, fore and hindwings are closely similar, the latter being without an anal fan, and both pairs are capable of being shed with ease.

Characters. Insects organized into social communities, living in large nests, and consisting of workers, soldiers, larvae of winged individuals (nymphs) and mature winged individuals both male and female.

Head large and well rounded in the workers and soldiers, always much larger than the prothorax; smaller by comparison in the winged forms. *Antennae* moniliform, composed of from 30 down to 12 segments. *Compound eyes* small, placed wide apart, always present in the winged forms and their larvae; workers always blind; soldiers usually blind, sometimes with very small eyes. *Ocelli* present in the winged forms, two in number, the median ocellus always absent; workers and soldiers without ocelli. *Mouth-parts* of typical mandibulate form. *Mandibles* large, toothed, asymmetrical in workers and winged forms, often very large in the soldiers. *Maxillae* with soft galea, lacinia with a hard bidentate tip, palp with 5 segments. *Labium* of primitive form, with separate glossae, paraglossae and 3-segmented palpi.

Thorax mostly reduced in size, especially in the workers and soldiers; originally it was large and convex, as in *Mastotermes*. *Meso-* and *metathorax* of about equal size, small in the workers and soldiers, larger in the winged forms and their larvae. There are two pairs of thoracic *spiracles*. *Legs* formed for walking and running; coxae well developed, trochanters very small, femora strong, tibiae slender, tarsi short, composed of either four or five segments, all of which, except the last, are excessively short; the tarsi end in two strong claws, but an empodium is seldom present.

PLATE 9

TERMITARIA OR NESTS OF WHITE ANTS

Order ISOPTERA

1. Termitarium of *Eutermes palmerstoni* Hill. Western Australia. Height 18 feet.
2. Termitaria of *Hamitermes wilsoni* Hill. Townsville, North Queensland.
3. Termitarium of *Hamitermes silvestrii* Hill. Townsville, North Queensland; end of nest removed to show interior.
4. Termitarium of *Hamitermes meridionalis* Frogg. Northern Australia. Height 10 feet.

G. F. Hill photo.

TERMITARIA OR NESTS OF WHITE ANTS

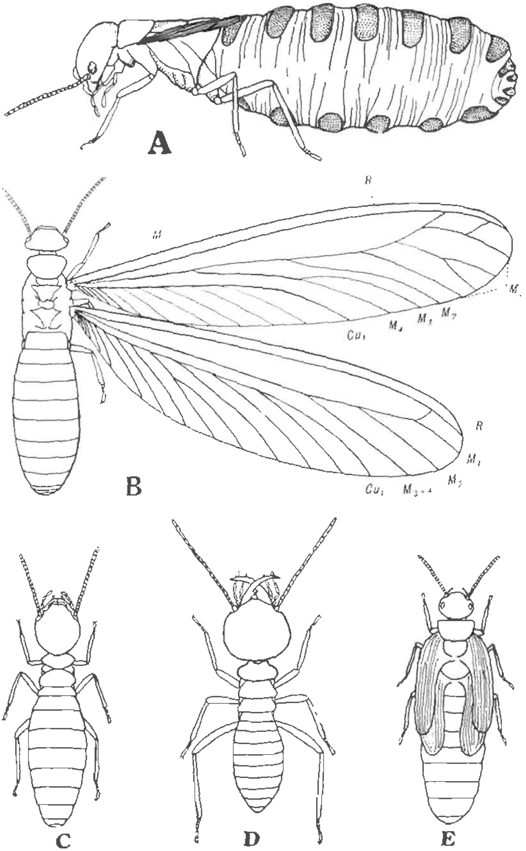

Fig H1. *Hamitermes silvestrii* Hill, tropical Australia. Fam. Termitidae. A, neoteinic queen, lenght 12 mm.; B, winged male, length of forewing 15 mm; C, worker, length 4 mm.; D, soldier, length 4.5 mm.; E, nymph, length 7 mm. Lettering as in fig. A8, p. 22. [*A. Tonnoir del.*

For nest of this species, see pl. 9, fig. 3.

W i n g s, when present, long and narrow, always much longer than the body, and usually fore and hind wings closely similar. In the oldest form (*Mastotermes*, fig. H3), the fore and hind wings are strongly dissimilar, the forewing having a very small cultriform clavus, similar to that of Blattidae but much reduced, while the hindwing has an anal area of considerable size, which folds strongly under the rest of the wing. *Venation* reduced except in *Mastotermes*, in which all the veins are present and greatly branched, and a complete meshwork of irregular veinlets lies between them. Normally there are only three main veins in the wing, viz., *R*, *M*, and Cu_1; *Sc* is absent, Cu_2 and the anal veins reduced with the loss of the anal area. R and M may be simple or branched distally; Cu_1 usually has a number of obliquely descending branches. In most forms both fore and hind wings possess a *transverse suture* near the base, along which the break occurs when the wings are cast off; in *Mastotermes*, this suture exists only on the forewing.

The remarks made on the structure of the media in Orthoptera (p. 88) apply with equal force to the wings of *Mastotermes* (fig. H3).

A b d o m e n softly chitinized, especially in the workers; in shape, more or less fusiform, more elongated in the nymphs and winged forms than in the workers and soldiers. *Spiracles* eight pairs, on segs. 1-8, except in the queens, which have only six pairs. Males with a pair of short ventral styles on seg. 9. Females usually without ovipositor; a complete but reduced ovipositor is present in the female of *Mastotermes*, hidden beneath a broad protecting plate formed from the seventh abdominal sternite. *Cerci* always present, very short, hairy. *Malpighian tubules* six to eight in number (more in the larvae).

Life History. The Termites always live in social communities, each of which is contained in a single nest or *termitarium*, (pl. 9), built by the workers out of finely masticated wood or earthy material cemented together by the sticky salivary secretion. Such a nest may be merely a series of meandering galleries in wood, without any plan, or a similar nest in open treeless land, or placed underground around the roots of a tree; or it may be a much more complicated and carefully designed home, with numerous stories horizontally arranged, having special exits and entrances, and even with specially constructed and carefully ventilated outside walls. Some of the nests of the higher types are of great size, reaching to as much as 18 feet in height (*Eutermes palmerstoni* Hill (pl. 9, fig. 1).

In each nest (except that of *Mastotermes*, where no queens are as yet known to exist), the following castes may be distinguished (fig. H1):—

(1) *The Royal Pair.* These are the original male and female whose numerous progeny form the colony. They are usually kept apart in a special royal cell. The King remains much like an ordinary winged individual, except that he casts off his wings before pairing. The fertile Queen (fig. H4) often swells up to an immense size; the first six abdominal segments are greatly extended, and their small tergites and sternites show up strongly as brown plates on the white skin. The number of *eggs* laid by one queen is often enormous; in shape they are oval or cylindrical with rounded ends.

(2) *The Workers* (fig. H1, C). These are to be distinguished by their general soft, whitish, larviform appearance. They have strong mandibles of normal shape, and are wingless and quite blind. They

are sexually undeveloped. Their functions are to build the nest, to keep it clean, to tend and feed the young, and to attend upon the Royal Pair.

(3) *The Soldiers* (fig. H1, D). These are a specialized caste of workers, distinguished at once by their hard heads of large size, and by their very large, projecting mandibles. Their chief function is to defend the nest from the attacks of its enemies, the most formidable of which are bands of true ants. This they do by rushing to the breach and ramming their large heads into it; they also use their large jaws to great advantage. In the family Termitidae the soldiers are sometimes of the *nasute* type (fig. H2), i.e., they are provided with pear-shaped heads more or less produced anteriorly, above the mandibles, into a narrow, snout-like process, at the end of which a duct opens for the discharge of a sticky fluid. This fluid is normally used as a kind of cement in the building of the nest; in some cases, e.g., *Eutermes*, it can be discharged violently to repel attackers.

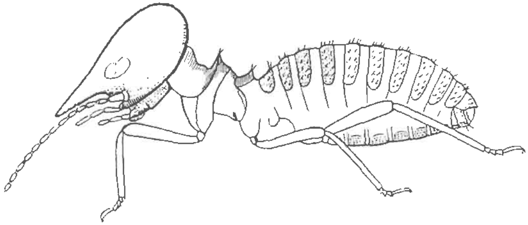

FIG. H2. *Eutermes vernoni* Hill. Australia. Fam. Termitidae. Nasute soldier. Length 3 mm. [*R. J. T. del.*

(4) *Sexual or Winged Caste* (fig. H1, B, E). In the deeper levels of the nest there are to be found numerous larval forms of a more elongated shape than the workers. These are the larvae of the future winged individuals, male and female. They pass through six instars, the wing-buds appearing when they are about half-grown, and increasing in size with each moult. They are then known as "nymphs". In many nests they number countless thousands; finally, maturing all at the same time, they may be seen "swarming", or issuing from the nest like a steadily ascending stream of smoke. Some species swarm at any time of the day, usually during or just after rain; others swarm only after dark. It is these latter only which are attracted to light and often make themselves such a nuisance in houses, falling upon everything and shedding their wings everywhere. The males can generally be distinguished by the ventral styles on the ninth abdominal segment.

(5) *Neoteinic Royalties* (fig. H1, A). Besides the above four regular castes, there are also sometimes present what are known as *neoteinic royalties*, or substitution kings and queens, which have been reared from selected nymphs by special feeding, to take the place of the original king or queen if either of them happens to die. These neoteinic royalties can always be distinguished by having complete wing-sheaths, similar to those of nymphs, instead of the tiny basal remnants of wings left on

the true royalties when their wings are cast off. Neoteinic queens, too, seldom swell up as much as true queens, nor do they lay so many eggs, so that a number of them are sometimes required to replenish the nest.

Distribution. White ants are abundant throughout Australia, but much rarer in Tasmania and New Zealand, where only a few species of Calotermitidae are known to occur. Australia possesses 111 described species, including four from Tasmania; only three species are recorded from New Zealand.

Economics. Because of their continual attacks upon wood, the Termites constitute in Australia an economic problem of the first magnitude. The annual losses caused by damage to houses, fences, railway sleepers, etc., must run into many thousands of pounds. Special protecting plates have to be used covering the foundations of houses, which often have also to be raised high above the ground. Railway sleepers are treated with a poisonous arsenical solution. Termites also attack fruit trees, which they hollow out until a main limb collapses from weakness. As they always work in the dark, the damage they do to the floors and walls of wooden houses is not at first apparent, and they will often reduce a house to a mere skeleton before their presence is detected. In the Northern Territory, the gigantic *Mastotermes* does immense damage, nothing being safe from its attacks. It has even been known to eat through lead piping, and once completely hollowed out the insides of some bonzaline billiard balls! Around Sydney the species responsible for most of the damage is *Coptotermes lacteus* Frogg.; it makes carefully covered galleries in fences and houses. The Tasmanian and New Zealand species do little or no damage.

Fossil History. The fossil record is evidently very imperfect, the only true Isoptera known belonging to the Tertiary Epoch. The most interesting of these are the winged forms found in the Oligocene Beds of the Isle of Wight, England, which have been placed in the genus *Mastotermes* (pl. 6, fig. 7), at present confined to tropical Australia.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order ISOPTERA 119 (3)

1. Mastotermitidae 1 (0)
2. Calotermitidae 30 (3)
3. *Termitidae 88 (0)*

The Order is divisible into three families, all of which are found in Australia, though only the Calotermitidae occur in New Zealand. The Mastotermitidae stand far apart from the other two, which are fairly closely allied. The following key will distinguish the families:—

1. Tarsi with 5 segments; hindwing with a large anal area, folded under the rest of the wing when at rest. Fam. 1. Mastotermitidae
   Tarsi with 4 segments; hindwing similar to the fore, without a folded anal area. 2
2. Wings with *R* branched; soldiers provided with powerful mandibles carrying internal teeth. Fam. 2. Calotermitidae
   Wings with *R* simple; soldiers with less powerful mandibles, generally not provided with internal teeth. Fam. 3. Termitidae

Family 1. **Mastotermitidae** [Aus. 1, N.Z. 0]. The only known representative of this family at the present day is *Mastotermes darwiniensis* Frogg. (pl. 6, fig. 7), the Giant Termite of tropical Australia. These insects construct nests up to twenty inches in diameter, mostly underground, eating out the roots of trees and working up the trunk; they also do immense damage to woodwork and buildings of all kinds. No true queen has yet been found in the nest, and the males and females are very much alike. The wing-venation, as can be seen from fig. H3,

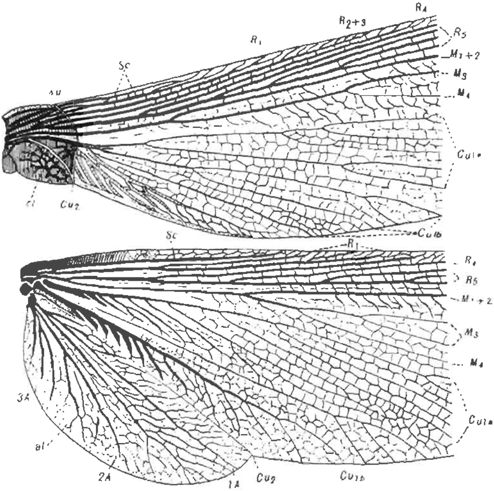

FIG. H3. Basal three-fifths of wings of *Mastotermes darwiniensis* Frogg. Tropical Australia. Fam. Mastotermitidae. Lettering as in fig. A8, p. 22, except *al*, anal lobe; *cl*, clavus; *su*, transverse suture. Total length of forewing 27 mm. [*R. J. T. del.*

is very complex, and of a much more archaic type than that of other Termites. The forewing has a well-marked transverse suture near the base (fig. H3, *su*), but this is not present in the hind. The venation is derivable from the Blattoid type, simply by reduction of the anal areas of both wings, the cultriform clavus of the forewing (fig. H3, *cl*) being reduced to a small hard basal scale, while the anal fan of the hindwing (fig. H3, *al*), though still large, is much smaller than in the Blattidae. The eggs are laid in masses of twenty or more stuck together in two parallel rows.

Family 2. **Calotermitidae** [Aus. 30, N.Z. 3]. This family contains the three genera *Stolotermes*, *Porotermes* and *Calotermes*, with small to moderate-sized species which live in logs and dead trees in the forest. The commonest of the three New Zealand species is *S. ruficeps* Broun, a small species with reddish head and dark wings; the other two belong to the genus *Calotermes*. Tasmania has one species of *Stolotermes*, *S. brunneicornis* Hag., one of *Porotermes* and two of *Calotermes*. Two species of *Porotermes* occur in Australia, also numerous species of *Calotermes*; this latter genus, found quite commonly in the bush, is remarkable in having no true workers, the nymphs doing all the work of the nest.

Family 3. **Termitidae** [Aus. 88, N.Z. 0]. All the Australian species which are of economic importance are included in this family. *Coptotermes lacteus* Frogg. has already been mentioned as causing much damage to houses

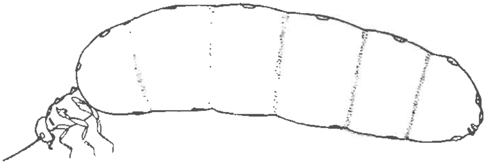

FIG. H4. *Coptotermes lacteus* Frogg., Australia. Fam. Termitidae. Fertile Queen. Length 17 mm. [*A. Tonnoir del*

and fences in New South Wales; in the bush it forms large, dome-like nests up to six feet in height. *Hamitermes* contains a number of tropical species, including the widespread *H. silvestrii* Hill (fig. H1) and *H. meridionalis* Frogg., the famous meridional or magnetic termite of Northern Australia, whose nests are formed as huge mounds pointing always north and south, with broad faces to the east and west (pl. 9, fig. 4). The dominant genus is *Eutermes*, with no less than 32 Australian species. Most of these make rather small nests on the ground or on the trunks or limbs of trees, the well-known "nigger-heads" being familiar examples of their work. *E. palmerstoni* Hill, found in Western Australia, forms a huge, pillar-like nest up to 18 feet in height (pl. 9, fig. 1).

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CHAPTER XII

Order DERMAPTERA

(Earwigs).

The Earwigs, which for a long time were considered as being only of family rank within the Order Orthoptera, are now admitted by all careful students to deserve true ordinal rank. They may be at once recognized by their elongate shape, the mobile and telescopic abdomen, the presence of the forceps and the remarkable form of their wings.

Until recently, their classification was in a hopeless muddle; but the

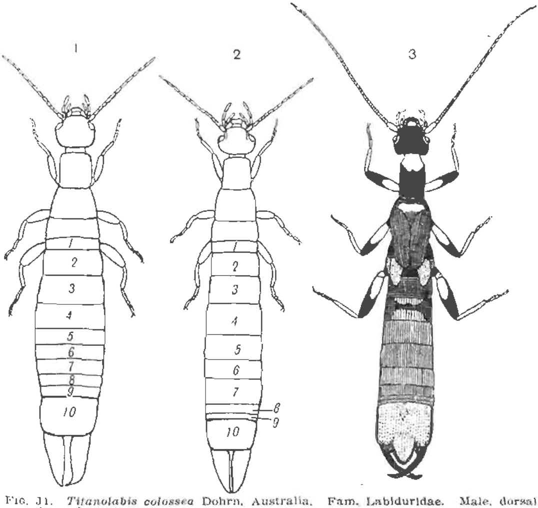

FIG. 31. *Titanolabis colossea* Dohrn, Australia. Fam. Labiduridae. Male, dorsal view. Length 40 mm.
FIG. 32. The same, female, dorsal view, with segs. 8 and 9 of abdomen withdrawn from beneath seg. 7. Length 39 mm. 1-10, abdominal tergites.
FIG. 33. *Apachyus australiae* Till., Australia. Fam. Apachyidae. Male, dorsal view. Length 37 mm. [R. J. T. del.

work of Burr and others has shown that reliable characters are to be obtained for systematic work, provided a little care in dissection is taken. External characters, such as the presence or absence of wings, the shape of the forceps, the number of segments in the antennae, are of little or no use in this Order. The student who would understand them must be prepared to make good microscopic mounts of the parts on which the modern divisions of the Order are based.

The Dermaptera, as now constituted, contain not only the true Earwigs, but also two very rare parasitic insects, *Arixenia* from Malaya and *Hemimerus* from West Africa. As these do not concern us here, the definition of the Order given will be that for the Earwigs only; strictly speaking, these should be considered as forming only the Sub-order Forficulina.

Characters. H e a d small to medium, smooth, more or less rounded or swollen; *compound eyes* present, separated; *ocelli* absent; *antennae* filiform, with from ten to as many as 50 segments. *Mouth-parts* normally mandibulate, the *mandibles* well developed, the *maxillae* of primitive type, with five-segmented palpi, the lacinia with hardened apical teeth, the *labium* with a pair of unfused inner lobes and three-segmented palpi.

T h o r a x with its three segments quite free, narrow in the wingless forms. *Legs* short, formed for running, the coxae placed wide apart, the tarsi with only three segments and ending in a pair of claws, with or without an empodium (fig. J4, C).

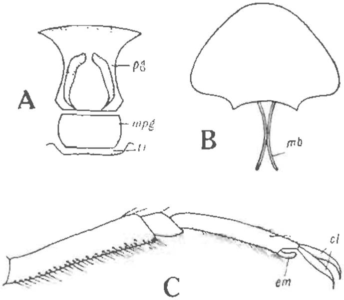

FIG. J4. *Anisolabis littorea* Wh., New Zealand. Fam. Labiduridae. A, opisthomeres; *mpg*, metapygidium; *pg*, pygidium; *tl*, telson; B, ninth sternite and attached manubrium (*mb*) of male; C, hind tarsus, showing claws (*cl*); and empodium (*em*). All much enlarged. [*R. J. T. del.*

W i n g s (fig. J5, B) when present, of highly specialized form, the *forewing* being a short, hardened *elytron* which serves only as a protecting cover to the hind, the latter being a large, fan-like wing, consisting mostly of a highly expanded anal area, and capable of being folded not only radially or fan-wise, but also cross-wise along concentric lines; the total effect of this folding is that this wonderful wing can be tucked away into such a minute compass that the small elytron covers all but its extreme tip. *Venation* as shown in fig. J5.

Abdomen telescopic, the segments being strongly imbricated one within the other, the tergites and sternites strongly chitinized half-rings, freely movable, overlapping at the sides, separated by broad soft pleura and also by wide, soft, sutural areas between the segments; first tergite a narrow strip attached to metanotum, not generally visible in the natural position; first sternite a short, squarish flap projecting below second. Abdominal segments increasing in length from before backwards, also in breadth, from 1 to 7 or 8. The male (fig. J1) has nine or ten abdominal segments visible externally, the female (fig. J2) only seven or eight; in reality, there are ten in each case, 8 and 9 being very narrow in the female, and hidden beneath 7. Last tergite a large, strongly chitinized plate, very convex, and carrying the *cerci*, which form a pair of unsegmented forceps. *Spiracles* eight pairs, small, hidden in the pleural membrane of segs. 1-8. Male with a *manubrium* (fig. J4, *mb*) attached to base of ninth sternite, and with a single or double *penis* (fig. J5, A, *pe*). Female with or without vestiges of original gonapophyses attached to sternites 8 and 9. Shape of forceps usually differing in the two sexes. *Malpighian tubules* numerous.

When the forceps of an earwig is carefully removed, there will be seen, projecting downwards from the tenth tergite, and protecting the anus from above, either one, two or three separate, chitinized plates of small size, the number three being only found in the most archaic types. These are called the *opisthomeres** (fig. J4, A), and represent the *supra-anal plate* (*pygidium*) and two segments of the reduced *appendix dorsalis* (*metapygidium* and *telson*). They are of great importance in classification, and a mount should be made of them for each species. If, as is preferable, a male be chosen for dissection, then the *penis* will be found projecting between the ninth and tenth sternites; it should be removed and mounted. Further, if the ninth sternite be removed and mounted, there will be seen projecting from its base a transparent chitinous lobe supported on a stiff marginal framework, and either rounded or elongated in shape; this is the *manubrium* (fig. J4, *mb*). Its function is not known.

Life History. The *eggs* are broadly oval, and are usually laid in the soil, more rarely under the bark of trees. The young earwig, on hatching, is very similar in general shape to the adult, but the forms in which the adult is winged do not show any definite traces of wing-pads until the second instar. The total number of instars appears to vary from four to six. Earwigs are said to take great care of their eggs. All the species seem to be practically omnivorous, but the greater part of their food consists of vegetable material.

Fossil History. The only known fossil earwigs are from Tertiary strata, both Oligocene and Miocene; nearly all the species are placed in a single genus, *Labiduromma*, which does not differ materially from recent forms.

Distribution. Comparatively little is known of the Dermapterous fauna of Australia and New Zealand. Forty-five species have been described from Australia, representing six families; most of these are exceedingly rare in collections. New Zealand has only three species, and Norfolk Island one, all belonging to the Labiduridae. New Guinea is rich in Earwigs, and it is clear that these faunas are merely southern extensions of the much richer Austro-malayan tropical fauna.

*Considered by some authors as representing the eleventh tergite, twelfth tergite and telson respectively.

Economics. None of the native species are harmful. The introduction of the common European Earwig, *Forficula auricularia* L., into New Zealand and Tasmania promises to be a great misfortune. This insect, freed from its natural enemies, is spreading with great rapidity, and is becoming a serious pest to fruitgrowers, gardeners and householders. In New Zealand attempts are being made to introduce the parasitic Tachinids *Digonochaeta setipennis* Fall. and *Racodineura antiqua* Meig.; the former lays young larvae freely in the earwigs' haunts, and these seek their prey actively and bore into them; the latter lays hard, black, seed-like eggs on the earwigs' food, and, when these are swallowed, the young larva hatches out inside its host.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order DERMAPTERA 42 (3)

[Suborder ARIXENINA]	[ARIXENIDAE]
[Suborder HEMIMERINA]	[HEMIMERIDAE]
Suborder FORFICULINA 42 (3)	I. LABIDUROIDEA 25 (3) 1. PYGIDICRANIDAE 7 (0) 2. LABIDURIDAE 18 (3) II. APACHYOIDEA 1 (0) 3. APACHYIDAE 1 (0) III. FORFICULOIDEA 16 (0) 4. LABIIDAE 12 (0) 5. CHELISOCHIDAE 2 (0) 6. FORFICULIDAE 2 (0)

The Order Dermaptera, as now constituted, contains not only the true Earwigs, forming the Suborder Forficulina, but also two very rare, parasitic insects, *Arixenia* from the Malay Archipelago and *Hemimerus* from West Africa; these are wingless forms with the eyes much reduced or entirely absent and the cerci feebly chitinized and not forming a hardened forceps. To each of these insects a separate suborder is allotted.

The true Earwigs, or Suborder Forficulina, are divisible into three superfamilies, as follows:—

1. Penis of male double; the three opisthomeres all present, either as separate plates, or fused together to form a horizontal squame. 2
   Penis of male simple; only the pygidium well developed, often with complex processes; the metapygidium and telson degenerate, vestigial. III. FORFICULOIDEA

2. Body normally convex; forceps not sickle-shaped; opisthomeres all preserved as separate plates, though the telson may be very narrow. I. LABIDUROIDEA
   Body excessively flattened; forceps sickle-shaped; opisthomeres fused together to form a horizontal squame. II. APACHYOIDEA

Superfamily I. LABIDUROIDEA (PROTODERMAPTERA)*

Two families only are included in this group; both of these are found in Australia, but only the Labiduridae in New Zealand.

Femora compressed and usually keeled; the three opisthomeres all about equally well developed. Fam. 1. PYGIDICRANIDAE
Femora neither compressed nor keeled; pygidium relatively large, the other two opisthomeres much smaller. Fam. 2. LABIDURIDAE

Family 1. **Pygidicranidae.** [Aus. 7, N.Z. 0]. The Australian species belong to the genera *Pygidicrana*, *Dicrana*, *Pyge*, and *Echinosoma*. They all possess elytra and antennae with many segments (25 to 30); the last-named genus has the body covered with short stiff bristles.

Family 2. **Labiduridae.** [Aust. 18 N.Z. 3]. This family is well represented in Australia, mostly by blackish earwigs, quite wingless; three species occur in New Zealand and one in Norfolk Island. The best known forms are the species of the closely related genera *Titanolabis*, *Gonolabis*, *Anisolabis*, and *Euborellia*. The males have the manubrium elongated (fig. J4, B). The large, black, wingless *T. colossea* Dohrn (figs. J1, 2) is not uncommon in Australia; it attains a length of 40 mm. *A. littorea* Wh. (pl. 7, fig. 16) about an inch in length, is the common wingless earwig of the New Zealand coast; it is found under stones and logs. The genus *Anisolabis* received its name from the unequal development of the two arms of the forceps in the male (pl. 7, fig. 16); in the female, the forceps are symmetrical. *E. tasmanica* Bormans is a smaller earwig, quite black, and with vestiges of elytra, which occurs rather rarely on the mountains of Tasmania. The genus *Labidura*, in which the wings are well developed, is represented in Australia by *L. truncata* Kby., *L. pluvialis* Kby., and the cosmopolitan *L. riparia* Pallas, which burrow in the sandy banks of rivers.

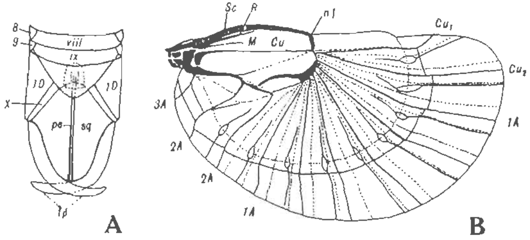

FIG. J5. *Apachyus australiae* n.sp. Till.† Australia. Fam. Apachyidae. A, ventral view of end of abdomen of male, enlarged, showing the huge squame (*sq*) formed of the three fused opisthomeres, and forceps (*fp*) in position of rest; the double penis (*pe*) lies in a narrow groove along the middle of the squame; 8, 9, 10 abdominal tergites; viii, ix, x, the corresponding sternites (*R. J. T. del.*); B, hindwing, expanded (enlarged). Lettering as in fig. A8, p. 22. [*A. Tonnoir del.*

Superfamily II. APACHYOIDEA (PARADERMAPTERA).

Only one family is known in this group; it contains a single genus, only found in the forests of Papua and Eastern Australia.

Family 3. **Apachyidae.** [Aus. 1, N.Z. 0]. This family contains brightly

*Dr. M. Burr uses the terms Protodermaptera, Paradermaptera and Eudermaptera for the three superfamilies here designated as Labiduroidea, Apachyoidea and Forficuloidea respectively. The alteration has been made to bring the superfamily terminology of this Order into line with the scheme adopted in this book, viz. that a superfamily name should be formed by adding *-oidea* to the stem of the type-genus of the principal family within it. Dr. Burr's terms, which are more suitable to suborders than to superfamilies, are given in brackets as alternatives.

†See Appendix, p. 112.

coloured earwigs of large size, having antennae with 30 to 50 segments, and the body extraordinarily thin and flattened. This remarkable structure is correlated with a bark-haunting habit, the species being found under the bark of forest trees: they are able to run with great rapidity, and penetrate with ease between the layers of bark, however close they may be. *Apachyus australiae* n.sp. Till.* (pl. 7, fig. 17) occurs in New South Wales, in the forests of the Dorrigo Plateau and Barrington Tops; it is a very handsome insect, with strongly contrasted colouring of black, reddish-brown and creamy-white.

Superfamily III. FORFICULOIDEA (EUDERMAPTERA).

Three families of this group are represented in Australia: they are distinguished as follows:—

1. Second tarsal segment normal, neither lobed nor dilated. Fam. 4. LABIIDAE
   Second tarsal segment either lobed or dilated. 2
2. Second tarsal segment with a narrow lobe like an empodium, produced forward beneath the third. Fam. 5. CHELISOCHIDAE
   Second tarsal segment bilobed. Fam. 6. FORFICULIDAE

Family 4. **Labiidae.** [*Aus. 12, N.Z. 0*]. *Several genera of this family are* represented in Australia, but most of the species are rare. The genus *Marava* is represented by four species having perfect elytra and 15-segmented antennae; of these, *M. grandis* Dubrony is the best known, ranging from Malaya through New Guinea into N. Australia. *Nesogaster ruficeps* Er., an earwig with 12-segmented antennae, keeled elytra, and shining, smooth body, occurs in Tasmania, Australia, and Fiji. *Prolabia arachidis* Yersin is a cosmopolitan species found in Australia.

Family 5. **Chelisochidae** [Aus. 2, N.Z. 0]. Two species of *Chelisoches* from N. and NW. Australia are the only native species in this family. The widespread *Chelisoches morio* Fab. has been taken in New Zealand, where it is clearly an introduced species.

Family 6. **Forficulidae** [Aus. 2, N.Z. 0]. Only two genera are native to Australia, viz., *Doru*, in which the pygidium carries a spine, and *Elaunon*, in which the same is absent. Each genus is represented by a single species. The introduced European pest, *Forficula auricularia* L., may be recognized by its complete elytra and wings, its 12-14 segmented antennae, and by the strongly depressed and basally dilated forceps.

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APPENDIX.

APACHYUS AUSTRALIAE *n.sp.* (figs. J3, J5). Male. Length 37 mm., antennae 17 mm., forceps 5 mm. *Head* all black, except clypeus which is creamy-yellow; antennae pale yellowish at bases shading to pale yellowish-brown distally; palpi yellowish-brown. *Thorax* black with large basal area of pronotum and smaller basal area of mesonotum white; femora black with large oval basal area white above; tibiae and tarsi pale yellowish brown. *Elytra* black; exposed portion of hindwings greyish. *Abdomen* with seg. 1 hidden, seg. 2 blackish above, seg. 3 reddish-brown shaded with black, segs. 4-9 reddish brown, seg. 10 pale yellowish-brown; forceps black; underside of abdomen more or less uniformly reddish-brown. *Types*, holotype male and series of paratypes (mostly immature) from Dorrigo Plateau, N.S.W., in Cawthron Institute Collection, Nelson, N.Z.

CHAPTER XIII

Order PERLARIA

(or PLECOPTERA)

(Stone-flies).

THE Stone-flies form a small but well-marked Order related to the Orthoptera, with which they agree in general form, in the presence of an anal fan on the hindwing, and in the long, flexible, filiform antennae. They differ, however, in having a very distinct venational scheme, in the comparative softness of their integument and wing-membrane, and especially in the larval form, which is truly aquatic and frequently possesses tracheal gills.

Characters. Four-winged insects of slow flight and very sluggish habits, only found near fresh water, usually near running streams or along the borders of lakes.

Head broader than long, sessile on the broad prothorax; *compound eyes* present, placed at the antero-lateral angles; *ocelli* present or absent; antennae always long, flexible, filiform, many-segmented. *Mouth-parts* mandibulate, the *mandibles* well formed in all our species (reduced to flat laminae in some genera in the Northern Hemisphere); *maxillae* well developed, with galea, lacinia and five-segmented palp; *labium* complete, with three-segmented palp.

Thorax with the three segments free, the *prothorax* large, with wide, flat pronotum; *meso-* and *metathorax* subequal. *Legs* strongly built, with short coxae, strong femora more or less flattened, slender tibiae without spurs, three-segmented tarsi with a pair of terminal claws and an empodium.

Wings very unequal, folding down closely over the back of the insect, with one tegmen (usually the left) closely enwrapping all but the basal portion of the other; generally the fore wings are longer than the hind and project beyond the tip of the abdomen. *Venation of a primitive type, with Sc simple or distally forked;* R_1 *simple;* Rs and M either two-branched or simple; Cu_1 either simple or with one or more distal branches; Cu_2 a weak, concave vein either in or just anterior to the anal furrow; forewing with short anal veins, $1A$ free, $2A$ and $3A$ more or less fused basally; hindwing with a more or less broad anal field containing five or more veins and folding beneath the rest of the wing; of these veins, at least three are developed from $3A$. In forewing, M is fused basally with R; in hindwing, Rs and M are fused for a space close to base. The system of cross-veins and veinlets is of considerable interest; a series of subcostal veinlets is often present; cross-veins may be present, irregularly placed, in all parts of the wing, but there is always a special set of strongly developed cross-veins

Plate 10

PLECTOPTERA AND PERLARIA

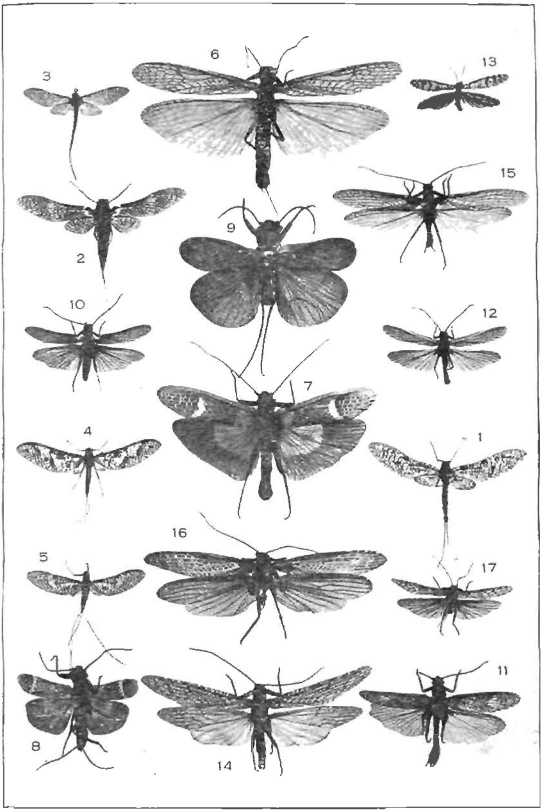
All figures natural size

Order PLECTOPTERA

1. *Ameletus ornatus* Eat. (Fam. Siphlonuridae), male subimago. N.Z.
2. *Oniscigaster distans* Eat. (Fam. Siphlonuridae), female subimago, N.Z.
3. *Tasmanophlebia lacustris* Till. (Fam. Siphlonuridae), male subimago. Aus.
4. *Atalophlebia versicolor* Eat. (Fam. Leptophlebiidae), female subimago. N.Z.
5. *Atalophlebia costalis* Burm. (Fam. Leptophlebiidae), female subimago. Aus.

Order PERLARIA

6. *Stenoperla australis* Till. (Fam. Eustheniidae), female. Aus.
7. *Eusthenia lunulata* Till. (Fam. Eustheniidae), female, Aus.
8. *Eustheniopsis venosa* Till., *form brachyptera* Till. (Fam. Eustheniidae), Aus.
9. *Thaumatoperla robusta* Till. (Fam. Eustheniidae), male, Aus.
10. *Austroperla cyrene* Newm. (Fam. Austroperlidae). N.Z.
11. *Tasmanoperla diversipes* Walk. (Fam. Austroperlidae). Aus.
12. *Tasmanoperla ruficosta* Till. (Fam. Austroperlidae), Aus.
13. *Dinotoperla fasciata* Till. (Fam. Leptoperlidae), Aus.
14. *Trinotoperla irrorata* Till. (Fam. Leptoperlidae). Aus.
15. *Trinotoperla australis* Till. (Fam. Leptoperlidae). Aus.
16. *Eunotoperla kershawi* Till. (Fam. Leptoperlidae). N.Z.
17. *Zelandoperla decorata* Till. (Fam. [illegible]). N.Z.



W. C. Davies photo.

PLECTOPTERA AND PERLARIA

situated between the basal portions of M and Cu_1 in forewing, and another set between Cu_1 and Cu_2; anal fan of hindwing devoid of cross-veins except in Eustheniidae.

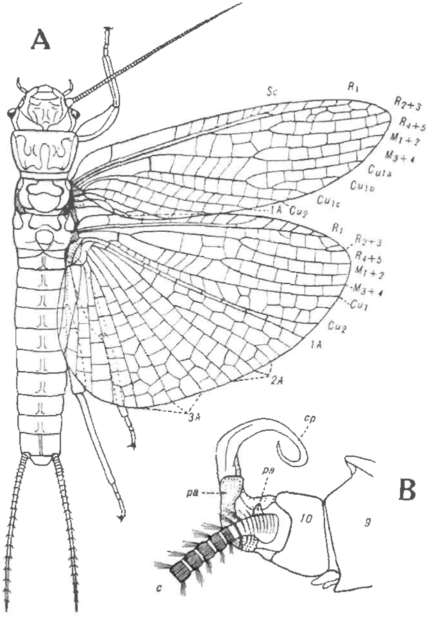


FIG. K1. A, *Eusthenia spectabilis* Wwd., female, Tasmania. Fam. Eustheniidae. Colour pattern omitted. *Length of forewing 23 mm.* Lettering as in fig. A8, p. 22. B, end of abdomen of male of *Eusthenia lacustris* Till., lateral view; 9, 10, last two abdominal segments; C, cercus (basal segments only); *cp*, copulatory process or hook developed from supra-anal plate; *pa*, paraproct with copulatory process and hook (×15). [*R. J. T. del.*

Comstock considered the venation of this Order to be very primitive, but was much puzzled by the fact that the media was never more than two-branched. Recent researches on Palaeozoic Protorthoptera, from which the Perlaria are a specialized offshoot, indicate that the most probable explanation of this is that, in the Perlaria, only the original, convex, two-branched MA of the Orthoptera is present, the simple, concave M of Comstock being entirely absent. We have, however, kept to Comstock's notation in the figures, as this difficult research is not yet completed. (See also pp. 58, 67.)

A b d o m e n soft, cylindrical or somewhat flattened, with ten complete segments and a pair of cerci with from one to many segments; vestiges of the larval gills are carried over on segs. 1-5 or 1-6 in Eustheniidae. Males (fig. K1, B) with ninth sternum undivided and without styles; tenth segment complete, usually annular, the tenth tergite and supra-anal plate often more or less fused, the latter often modified to form a hook-like copulatory organ (*cp*), which bends forward over the terminal segments and sometimes occupies a grove or pocket in the tenth tergite; paraprocts (*pa*) usually large, often fused with bases of cerci, frequently armed with copulatory hooks; penis present or absent, sometimes with parameres. Female without ovipositor. *Spiracles* eight pairs, on segs. 1-8. *Malpighian tubules* numerous.

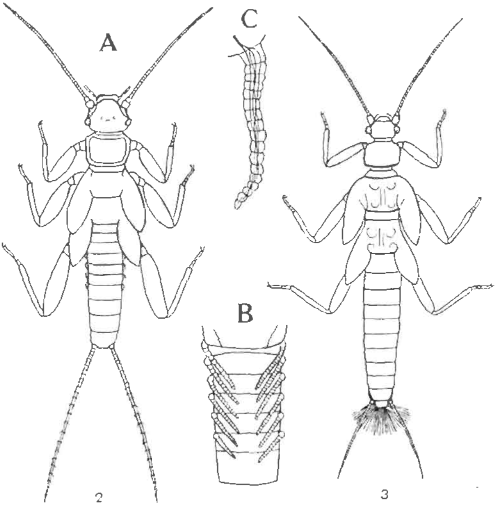


FIG. K2. A, larva of *Eusthenia spectabilis* Wwd., last instar, Tasmania. Fam. Eustheniidae. Dorsal view. Length 26 mm. B, ventral view of first seven *abdominal segments of same* (× 4), *to show* the six pairs of lateral gills in position. C, a single gill of same (× 10), with tracheae.

FIG. K3. Larva of *Megaleptoperla grandis* Huds., last instar, New Zealand. Fam. Leptoperlidae. Dorsal view. Length 23 mm. Note the rosette of gills around anus.

Life History. The early stages are entirely aquatic. The *eggs* are very numerous, small and seed-like, with a well-marked micropylar area; they are usually washed off in masses into running water by the female. The *larva* (figs. K2, K3) resembles the imago fairly closely, having the same general form, soft integument, long, flexible antennae,

mandibulate mouth-parts (with much shorter maxillary and labial palps) and cerci; *spiracles* absent, but *tracheal gills* present either on the thorax in the form of tufts, on the first five or six segments of the abdomen (paired lateral filaments) or arranged as a rosette around the anus; in some larvae no gills are present, and breathing takes place through the rectum. The number of instars is not known for certain, but appears to be usually six; the wing-sheaths develop normally, the fore generally partially overlying the hind. Most of the larval forms are very sluggish, clinging to rocks and stones beneath running water, especially in rapids and cascades, and feeding on minute particles of animal or vegetable matter. The larvae of Eustheniidae are, however, active, fast-running and carnivorous. At metamorphosis the larva climbs out of the water a little way, and the imago emerges with considerable rapidity. Brachypterous imagines are met with in a number of genera, usually in company with fully winged forms.

Distribution. The Stone-fly faunas of Australia and New Zealand are closely similar to one another and to that of Southern Chile and Patagonia, and consists of four families, three of which are confined to the Southern Hemisphere, while the fourth (Nemouridae) is world-wide. The fauna is essentially an Antarctic one, the Order being abundantly represented in Tasmania and New Zealand, but rarely met with on the mainland of Australia, except in the mountains. Many of the species emerge very early in the spring, some during the winter months (June to August).

Economics. The Stone-flies are of little economic value, but their larvae form valuable food for trout and other fresh-water fish.

Fossil History. No fossils which can be definitely assigned to this Order have so far been found in the Palaeozoic, the first clearly recognizable types being a few small wings and larvae found in the Upper Jurassic of Europe. A large number of the insects recently discovered in the Lower Permian of Kansas appear to be ancestral to both Perlaria and Embiaria, though they cannot be definitely placed in either Order. No fossil Stone-flies have as yet been discovered in Australia.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order PERLARIA 25 (22)

I. EUSTHENIOIDEA 9 (1)
- 1. Eustheniidae 9 (1)

II. LEPTOPERLOIDEA 14 (17)
- 2. Austroperlidae 4 (1)
- 3. Leptoperlidae 10 (16)

III. NEMOUROIDEA 2 (4)
- 4. Nemouridae 2 (4)

The four families found in Australia and New Zealand are best placed in three distinct superfamilies, which may be distinguished as follows:—

1. Anal fan of hindwing very large, its contour continuous with that of the rest of the wing; cross-veins present all over it. Larvae active, carnivorous, with five or six pairs of lateral filamentous gills on segs. 1-5 or 1-6 of abdomen. I. EUSTHENIOIDEA

Anal fan of hindwing not so large, its contour discontinuous with that of rest of wing, forming a break or re-entrant angle at end of *1A*; generally no cross-veins on it (rarely a very few present). Larvae sluggish, never with paired lateral gills on abdominal segments 2

2. Distal half of wings with cross-veins present, irregularly placed; no transverse cord present. II. LEPTOPERLOIDEA

Distal half of wings without cross-veins; a true transverse cord present at about middle of wing, formed by alignment of special cross-veins with short basal pieces of the branches of *Rs* and *M*. III. NEMOUROIDEA

Superfamily I. EUSTHENIOIDEA

Family 1. **Eustheniidae** [Aus. 9, N.Z. 1]. This family contains large and mostly brightly coloured Stone-flies with abundant cross-veins on all parts of the wings, including the space between Cu_2 and *1A*, and the anal fan of the hindwings, which are free of cross-veins in other families. The larvae (fig. K2) are flattened, usually of a green colour, more rarely brown or black with reddish or orange underside; they run rapidly about under rocks in streams and lakes. The paired segmental gills of the abdomen are short, whitish, moniliform filaments, folded obliquely beneath the flat ventral surface of the larval abdomen (fig. K2, B).

The genus *Stenoperla*, with narrow forewings, is represented by the very common, bright green *S. prasina* Newm. (pl. 2, fig. 5) in New Zealand and by the much rarer, dark brown *S. australis* Till. (pl. 10, fig. 6) in the mountains of Eastern Australia. The genus *Eusthenia*, found only in Tasmania, has much broader wings; it contains five species with beautiful red or purple colouring. The type of the genus is the somewhat variable *E. spectabilis* Wwd. (fig. K1) found chiefly in Southern Tasmania; *E. lunulata* Till. (pl. 10, fig. 7) is an allied species with a more definite pale lunule on forewings; *E. lacustris* Till. (pl. 11, fig. 5) is a smaller but very beautiful species found on the lakes of

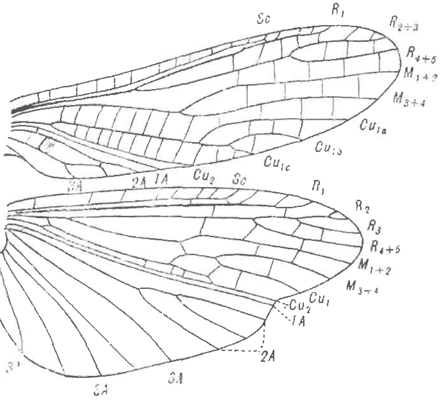


FIG. K4. Wing-venation of *Austroperla cyrene* Newm., New Zealand. Fam. Austroperlidae.

Cradle Mountain. All these have rich red hindwings bordered with purplish. The allied genus *Eustheniopsis*, with shorter and more bluntly rounded wings, occurs both in Tasmania and the mountains of South-eastern Australia; *E.*

venosa Till. (pl. 10, fig. 8), with strongly reticulate forewings and purple hindwings, is found in Victoria, and is also represented on Mt. Kosciusko by a peculiar brachypterous form (pl. 10, fig. 8). The wonderful *Thaumatoperla robusta* Till. (pl. 10, fig. 9) is a large black stone-fly with very broad wings and orange pronotum; it occurs very rarely in Victoria.

Superfamily II. LEPTOPERLOIDEA

The two families belonging to this group may be distinguished as follows:—

Forewing with *Sc* ending up at more than two-thirds from base, leaving a short pterostigmatic region beyond it. Anal fan of hindwing with 7-8 main veins (inclusive of *1A*); first branch of *2A* forked. Larvae without external gills. Fam. 2. AUSTROPERLIDAE

Forewing with *Sc* ending up at between one-half and two-thirds from base, leaving a long pterostigmatic region beyond it. Anal fan of hindwing with only six main veins (inclusive of *1A*); first branch of *2A* not forked. Larvae with gills arranged in a rosette around anus. Fam. 3. LEPTOPERLIDAE

Family 2. **Austroperlidae** [Aus. 4, N.Z. 1]. This small family contains only two genera, *Austroperla* in New Zealand and *Tasmanoperla* in Tasmania and South-eastern Australia. *A. cyrene* Newm. (pl. 10, fig. 10) is a common, very sluggish, black species with creamy-white costa on forewings, found all over New Zealand. *T. ruficosta* Till. (pl. 10, fig. 12) from Mt. Kosciusko superficially resembles it, but is chocolate brown with reddish costa and different venation. *T. diversipes* Walk. (pl. 10, fig. 11) and the much darker *T. thalia* Newm. are larger species with broader wings and long bodies, found in Tasmania. The larvae of this family are very sluggish, without external gills, and can be kept alive in captivity in a moist atmosphere.

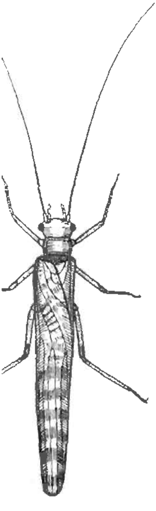


FIG. K5. *Dinotoperla carpenteri* Till., Australia, in position of rest. Fam. Leptoperlidae. Length 7 mm.

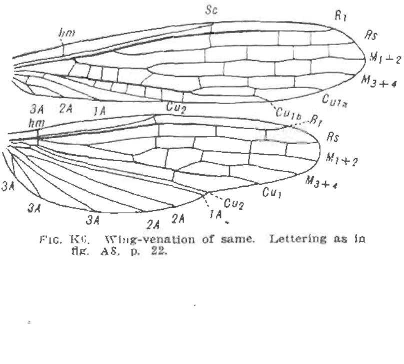


FIG. K6. Wing-venation of same. Lettering as in fig. A8, p. 22.

Family 3. **Leptoperlidae** [Aus. 10. N.Z. 16]. This is the dominant family of Stone-flies both in Australia and New Zealand. Most of the species are of rather small size. The Australian genera in general differ from their New Zealand relatives in having narrower hindwings. *Leptoperla beroë* Newm., the first species described in this family, is the rarest of all, being only found in restricted localities in Tasmania. Most of the Australian species belong to *Dinotoperla* and *Paranotoperla*; *D. carpenteri* Till. (figs. K5, 6) is one of two or three small, dull-coloured species found around Sydney in August and September. *D. fasciata* Till. (pl. 10, fig. 13) is a handsomely marked species found at high altitudes in Southern Queensland. Of much larger size are the brownish *Trinotoperla australis* Till. (pl. 10, fig. 15), the speckled grey *T. irrorata* Till. (pl. 10, fig. 14) and the fine, rich brown *Eunotoperla kershawi* Till. (pl. 10, fig. 16); the first two are found on the mountains of Eastern Australia, the last is confined to Victoria.

The New Zealand species belong to the genera *Zelandoperla*, *Zelandobius*, *Nesoperla* and *Megaleptoperla*, the last-named containing only the large, speckled grey species *M. grandis* Huds. (fig. K3). *Zelandoperla decorata* Till. (pl. 10, fig. 17) has the forewings strongly marked with dark fuscous areas around the cross-veins. This genus and *Nesoperla* have *Rs* simple, but *Zelandobius* has *Rs* with a short terminal fork. *Aucklandobius* is a peculiar offshoot from the last-named genus, found in the Auckland Islands; it has ample hindwings but shortened forewings.

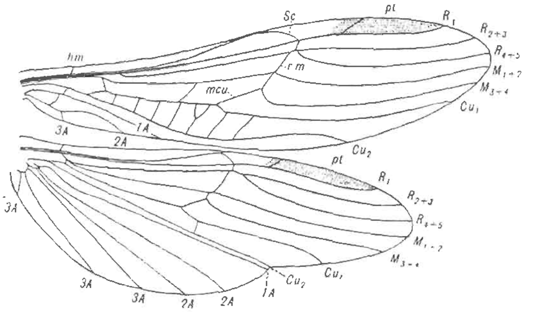


FIG. K7. Wing-venation of *Spaniocerca zelandica* Till., New Zealand. Fam. Nemouridae. Lettering as in fig. A8, p. 22, except *mcu*, medio-cubital cross-vein; *pt*, pterostigma; *r-m*, radio-median cross-vein. Note the transverse cord, of which *mcu* and *rm* form part.

Superfamily III. NEMOUROIDEA

Family 4. **Nemouridae** [Aus. 2. N.Z. 4]. The very small, insignificant Stone-flies comprising this family are easily recognized by the presence of the transverse cord (fig. K7) and the entire absence of cross-veins in the distal half of the wings. The cerci are very short (unsegmented in our genera). The larvae are very sluggish and (in our species) have no external gills. The genus *Spaniocerca* is represented by a few rather rare species in both countries, the best known being *S. zelandica* Till. (fig. K7). *Notonemoura latipennis* Till. is a rare New Zealand species with broader, semi-transparent wings.

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CHAPTER XIV

Order EMBIARIA

(Web-spinners)

This is a small but very distinct Order of archaic insects superficially resembling elongated Termites, but actually more closely related to the Perlaria. They are for the most part confined to tropical and subtropical countries, but one species has been found in Tasmania. They may be at once recognized by the swollen basal segment of the fore tarsi, which carries the gland from which the web is spun; the females are wingless, but the males generally possess two pairs of delicate, slender wings, placed very wide apart.

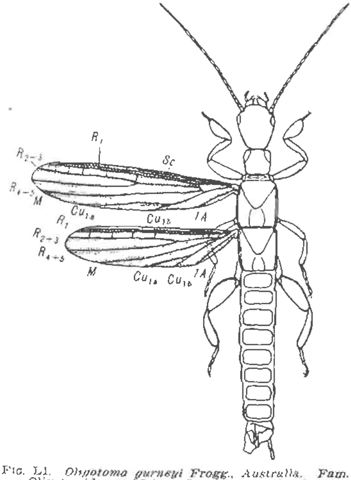

Fig. L1. *Oligotoma gurneyi* Frogg., Australia. Fam. Oligotomidae. Male. Lettering as in fig. A8, p. 22. Length 10 mm.

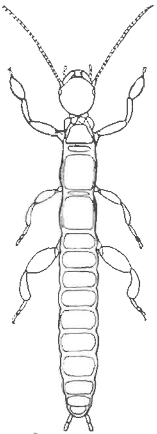

Fig. L2. *Oligotoma gurneyi* Frogg., Australia. Female. Length 11.5 mm.

Characters. Elongate, narrow, and weakly chitinized insects, very quick and agile. Males usually winged, females wingless.

H e a d oval; *compound eyes* present, *ocelli* absent; *antennae*, with from 12-32 segments, mostly similar in form, longer in males than in females. *Mouth-parts* of typical mandibulate form; *mandibles* strong, with sharp teeth; *maxillae* with separate lacinia and galea, and 5-segmented palpi; *labium* with short, pointed glossae, large rounded paraglossae, and 3-segmented palpi.

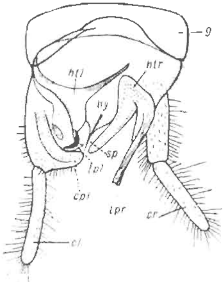

FIG. L3. End of abdomen of *Oligotoma glauerti* Till., Western Australia. Male, enlarged (× 36) to show asymmetrical parts: *g*. ninth tergite; *cl*. left cercus; *cpl*. copulatory process of same; *cr*, right cercus; *htl*. left, and *htr*. right hemitergite of seg. 10; *hy*. hypandrium (ninth sternite); *sp*. copulatory process of same; *tpl*. left; and *tpr*. right copulatory process of the two hemitergites of seg. 10. [*R. J. T. del.*

T h o r a x with short *prothorax* tapering anteriorly, *meso-* and *metathorax* elongated, so that the separate pairs of both legs and wings are placed far apart. Meso- and metanotum very differently formed in the two sexes, those of the wingless female bearing nearly rectangular sclerites covering almost the whole notal area, (fig. L2), while those of the male are divided into a large, triangular scutum, a smaller scutellum, and two large side-pieces (fig. L1). *Legs* with stout, short coxae, slender trochanters, very stout femora, slender and rather short tibiae without spurs, and short tarsi composed of three segments, the second very short; in the fore tarsi, the basal segment (metatarsus) is swollen into a large bulb, which contains the gland from which the web is spun. Tarsal claws present, but no empodium.

W i n g s folded back along the abdomen when at rest, elongate oval in shape, with rather narrow bases, but not detachable like those of Termites. Fore and hind wings similar, not connected in flight. *Venation*:—Veins in general bordered by dark pigment bands, separated by lighter areas. *Sc* simple, weak; R_1 strongly thickened, simple; *Rs* with 2-3 branches; *M* simple; Cu_1 with a thickened main stem, continued by Cu_{1b} just in front of the anal furrow, while Cu_{1a} forms an anterior branch, either itself branched or simple. Cu_2 absent. Anal area or clavus short and narrow, with a single anal vein. All the veins below R_{2+3} except Cu_1 may be merely indicated by pigment bands in the more reduced forms. Cross-veins absent or few, lightly indicated between R_1 and R_{2+3}, sometimes also between R_{2+3}, R_{4+5} and *M*.

A b d o m e n cylindrical, formed of ten well developed segments, the first eight approximately equal, segs. 9-10 shortened in the females, the ninth tergite much shortened in the males. *Cerci* two-segmented, (the left sometimes reduced or absent in males) with well developed

basipedites. Supra-anal plate and paraprocts absent or vestigial. The males have the tenth segment and cerci peculiarly modified for pairing; except in the primitive genus *Clothoda*, these parts are more or less asymmetrical, with their processes converging to the left side. Sternum of seg. 9 forming a subtriangular *hypandrium* (fig. L3, *hy*) without separate gonocoxites or styles, and ending toward the left in a copulatory process. Tenth tergite asymmetrically divided into two *hemitergites* (*htl*, *htr*), each of which carries a copulatory process of very distinct form (*tpl*, *tpr*); cerci asymmetrical, the left basipedite sometimes with a copulatory process (*cpl*). Penis absent.

Life History. The Embiaria are terrestrial insects, constructing their webs in the form of galleries on the ground, or under stones and rocks; some species live in the nests of ants and termites. They feed on vegetable débris. There may be only a few individuals together or many hundreds, but in no case are there any castes or organized societies. The insects progress naturally along these galleries, and so agile and swift are they that it is almost impossible to hold them in one's hand. The males are sometimes attracted to light. The *eggs* are oval; the young *larva* differs little from the adult in form. The number of instars is not known. The wings develop externally as small sheaths in the late larval forms.

Distribution. Only four species have been described from Australia, two from New South Wales and two from Western Australia. An undescribed species exists in Queensland and another in Tasmania. All belong to the genus *Oligotoma*. The Order is not represented in New Zealand.

Economics. These insects are both too rare and too delicately organized to be either harmful or beneficial. They appear to be only able to exist where the amount of moisture and warmth combined is exactly right for them.

Fossil History. The fossil record of the Order Embiaria is confined to a single species, *Oligotoma antiqua* Pict., found in Baltic Amber (Oligocene), and some subfossil forms found in Post-tertiary Copal. This history of the Order is, however, carried much further back by the recent discovery, in the Lower Permian of Kansas, of numerous wings evidently very closely related to true Embiaria, especially to such archaic genera as *Clothoda*. These may be considered as belonging to a new Order Protembiaria, which appears to have been a specialized offshoot of the older Protorthoptera.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order EMBIARIA 6 (0)

[EMBIIDAE]

I. OLIGOTOMIDAE 6 (0)

The Order contains fewer than one hundred species altogether, placed in two families, of which only the Oligotomidae have so far been found in Australia; they can be separated as follows:

R_{4+5} forked in both wings, or at least in hindwing. Sternite of first abdominal segment in female normal. Fam. EMBIIDAE

R_{4+5} simple in both wings. Sternite of first abdominal segment in female greatly reduced. Fam. I. OLIGOTOMIDAE

Family 1. **Oligotomidae** [Aus. 6, N.Z. 0]. The commonest species is *Oligotoma gurneyi* Frogg. (figs. L1, L2), whose larvae were found in large numbers in a mass of web spun in a sugar refinery in Sydney; the winged males are sometimes taken at light. *O. gracilis* Frogg., found near Wagga, N.S.W., is only known from the wingless female. *O. hardyi* Fried. and *O. glauerti* Till. (fig. L3) are two fine species found in Western Australia. An undescribed species occurs under stones near Brisbane, and another has been found forming a gallery under a large rock in the Bagdad Valley, Tasmania.

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CHAPTER XV

Order ZORAPTERA*

THIS Order, like the Protura, has not yet been discovered in Australia or New Zealand; but a short account is given here, as it seems highly probable that representatives of it will be found if carefully searched for. The first species were described by Silvestri in 1913 from specimens received from Ceylon, Java and West Africa; being wingless, these were originally placed as a new Order of Apterygota.

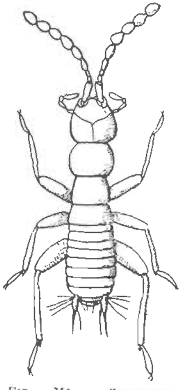

FIG. M1. *Zorotypus guineensis* Silv., West Africa. Fam. Zorotypidae. Length 2.2 m.m. (After Silvestri).

More recently, other species have been found in Florida associated with Termites in old logs, two castes occurring, the more numerous form being blind and wingless, the rarer form furnished with compound eyes, ocelli and four slender wings.

Characters. Small, agile, predatory insects, apterous or winged, the body somewhat elongate.

Head somewhat depressed; *antennae* rather short, with 5-9 segments; *compound eyes* and *ocelli* present in the winged forms, absent or vestigal in the wingless forms. *Mouth-parts* typically mandibulate; *mandibles* short, stout, toothed; *maxillae* with bidentate lacinia, well formed galea and 5-segmented palp; *labium* with large submentum, short, medially cleft mentum, complete glossae and paraglossae, and 3-segmented palpi.

Thorax with three segments decreasing in size from before backwards in the wingless forms; winged forms with mesothorax largest. *Legs* of simple walking type; tarsi with two segments, and ending in a pair of claws.

Wings, (fig. M2) when present, folded back along the abdomen, the forewing covering the hind, which is somewhat smaller but of similar shape; both wings long and narrow, with petiolate bases; apex of forewing wide and well rounded. *Venation* of *forewing* much reduced, with few or no cross-veins present; *Sc* present, close to costa;

*This Order is accepted provisionally only: the insects comprising it are closely allied to the succeeding Order Copeognatha, and the group is perhaps best considered as a Suborder of that Order.

R_1 *a strong vein bordering an elongate pterostigma distally* *Rs* partially fused with *M* near middle of wing, and both of these veins unbranched; Cu_1 fused basally with *M* and forked distally; Cu_2 and

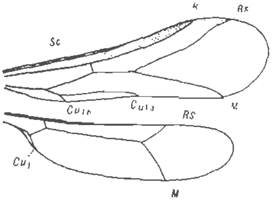

FIG. M2. Wings of *Zorotypus hubbardi* Caud., Florida. Fam. Zorotypidae. Lettering as in fig. A8, p. 22 (R. J. T. del.

anal veins absent. *Hindwing* with only one longitudinal vein formed by fusion of Rs and M, these two veins separating distally.

A b d o m e n with ten distinct, short segments, increasing in size from 1 to 8, 9-10 very small. *Cerci* present, short, unsegmented, ending in a stiff bristle; *supra-anal plate* and *paraprocts* absent or fused with tenth tergite. Males with ninth sternite absent, the eighth sternite forming a *hypandrium;* penis asymmetrical, bifid. Females without ovipositor.

The Order at present consists of a single family, Zorotypidae, containing the single genus *Zorotypus* (fig. M_1) with six species, in two of which the winged forms are known. The apterous forms, which are much the commoner and most likely to be discovered, are about 2 mm. long, pale creamy-white in colour for most of their lives, but becoming more darkly pigmented when mature; they run about with great rapidity, and much resemble small Psocids. Silvestri could discover no sexual organs in these forms, though both sexes can be recognized in the pigmented winged forms. It would seem, therefore, that these little insects have evolved a simple community system of winged sexual individuals and wingless, asexual workers. The Order may be considered as a connecting link between the Isoptera and Copeognatha. These insects should be searched for in termitaria and rotting logs.

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CHAPTER XVI

Order COPEOGNATHA

(or PSOCOPTERA)

(Psocids, Book-lice)

THIS Order contains mostly very small insects, characterized by their very specialized venation and by the development in the mouthparts of a pair of gouging organs or chisels unlike anything else found in the Class Insecta. They stand far apart from all other Orders except the Zoraptera and Anoplura, the former perhaps connecting them with

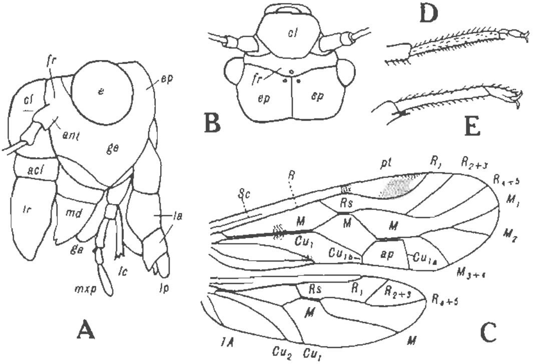

FIG. N1. A, head of *Psocus* sp., lateral view, after Enderlein; *acl*, anteclypeus; *ant*, antenna; *cl*, clypeus; *e*, eye; *ep*, epicranium; *fr*, frons; *ga*, galea; *ge*, gena; *la*, labium; *lc*, chisel; *lp*, labial palp; *lr*, labrum; *md*, mandible; *mxp*, maxillary palp. B, the same, dorsal view, after Enderlein; *cl*, clypeus; *ep*, the divided epicranium; *fr*, frons; the three ocelli are seen in position in the angles between the frons and epicranium. C, *Psocus lignicola* End., Australia. Fam. Psocidae. Wings with the main veins separated where they are fused in the actual specimen, so as to show the true interpretation of the venation. Lettering as in fig. A8, p. 22, except *pt*, pterostigma. D, *Myopsocus novae-zealandiae* Kolbe, New Zealand. Fam. Myopsocidae. Hind tarsus, showing the three segments, claws and empodium. E, *Caecilius flavistigma* Till., New Zealand. Fam. Caeciliidae. Hind tarsus, showing the two segments, claws and empodium. [C, D, E, original drawings, *R. J. T.*

the Isoptera, the latter being almost certainly specialized descendants from some early Copeognathous type.

Characters. Head (fig. N1, A, B) with the *epicranium* (*cp*) divided into two equal parts by a mid-longitudinal suture, and separated from the *frons* (*fr*) by a wide V-shaped suture; the three *ocelli* (usually present) in the angles so formed; *compound eyes* present, globular, placed far apart; *antennae* filiform or moniliform, with from thirteen to more than forty segments. *Clypeus* (*cl*) high and very convex, often strongly striated; a smaller *clypeolus* or *anteclypeus* (*acl*) separated off from it next to labrum. *Mouth-parts* complete, of mandibulate type, but with certain specializations; *mandibles* toothed, asymmetrical, the teeth of the one fitting into the gaps of the other; each also bears a corrugated chewing-plate; *maxillae* with normal galea and palp, the latter usually 4-segmented; close to the maxillae, but disconnected from them and running far back into the pharynx, these are a pair of long, slender *styliform appendages* or *chisels* (*lc*), considered by some authors as the highly specialized laciniae; they are capable of being extruded from the mouth for a considerable distance, and are used for gouging out the bark of trees or for cutting up fungal mycelia; *labium* very short, with complete glossae and paraglossae but unsegmented palpi; *hypopharynx* with median and side-lobes.

Thorax with *prothorax* small in the Eupsocida, large in the Parapsocida; *mesothorax* larger than *metathorax*, the scutum of each strongly divided into an anterior and two lateral portions, the scutellum but little prominent mid-dorsally, extending laterally into two triangular pieces bordered by prominent ridges or crests. *Legs* of normal walking type; tibial spurs often present; tarsi with 2-3 segments, (fig. N1, D, E) the basal segment long, the others short; distal segment ending in a pair of small claws and an empodium. *Spiracles* two pairs.

Wings (figs. N1, C, N2, A, C), generally held in a high, roof-like manner over the abdomen; forewing always larger than hind, the latter without a folded anal area. *Veins* either bare or carrying rows of hairs or scales. *Venation* of a simple but specialized type, with few or no cross-veins, but often with special fusions and bendings of the main veins. *Sc* and R_1 simple, the former much reduced (often absent in hindwing) the latter well developed, more or less concave distally where it bounds the pterostigmatic region. *Rs* two-branched, always touching or slightly fused with *M*. *M* fused basally with Cu_1, usually with three branches in fore, one or two in hind wing. Cu_1 in forewing usually distally branched; often the anterior branch, Cu_{1a}, arches strongly upwards, forming the boundary of a special area, the *areola postica* (fig. N1, *ap*), the upper portion of which may touch M or even be fused with it for a distance; Cu_1 in hindwing simple. Cu_2 a weak concave vein. Usually one anal vein present, rarely two.

Abdomen short, soft, with ten segments; the last two much reduced in size; *cerci* absent; *supra-anal plate* and *paraprocts* absent or fused with tenth tergite; ninth tergite sometimes with copulatory processes or hooks in male; eighth sternite well developed in both sexes, forming a hypandrium in male, a subgenital plate in female; *penis* of male bifid, asymmetrical; female without ovipositor. *Spiracles* eight pairs, on segments 1-8. *Malpighian tubules* four.

Life History. The *eggs* are flattened, and laid in masses, generally on leaves or bark, the female covering them over with a silken web. The *larvae* resemble the imago except for the absence of wings;

their antennae are long and their styliform appendages well developed; the tarsi are always 2-segmented. There are usually four larval instars, the wing-buds appearing at the second. The metamorphosis is rapid. The bark-feeding species can be easily reared to maturity in a dry glass tube. The imago is diurnal, but seldom flies unless disturbed.

Distribution. Of the ten known families, no less than eight are found either in Australia or New Zealand, six being common to both. The Psoquillidae are not yet known from Australia, while, curiously enough, the dominant *Psocidae* appear to be unrepresented in New Zealand. Except for a single native Australian species of Atropidae, this family and the Troctidae are only represented by introduced species. Thirty-two species are known from Australia, eighteen from New Zealand; many more would certainly be found by careful collecting in both countries.

Economics. Many of the species feed upon the mycelia of fungal growths on leaves, but in doing so they often become covered with fungal spores, and thus help to spread the infection further; some feed on the bark of trees, but do little damage. The most definitely injurious forms are the wingless book-lice or cabinet-mites, which are a pest in libraries and museums, and are particularly destructive to the smaller specimens in insect-collections.

Fossil History. Until recently, this Order was only known from Baltic Amber (Oligocene) where it was fairly well represented. A number of fine species are present in the new material from the Lower Permian of Kansas; they have a very complete venation combining the principal characters found in the two existing Suborders.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order COPEOGNATHA 32 (18)

Suborder PARAPSOCIDA 2 (3)

1. Lepidopsocidae 1 (2)	3. Atropidae 1 (0)
2. Psoquillidae 0 (1)	4. Troctidae.

Suborder EUPSOCIDA 30 (15)

5. Mesopsocidae 2 (5)	7. Caeciliidae 14 (9)
6. Myopsocidae 4 (1)	8. Psocidae 10 (0)

The Order is usually divided into two Suborders, the Trimera with 3-segmented tarsi and the Dimera with 2-segmented tarsi. This division is, however, an unscientific one, for the Dimerous Caeciliidae and Psocidae (which, with the South American Thyrsophoridae, make up the Suborder Dimera) are in all other characters very closely related to the Trimerous Mesopsocidae and Myopsocidae. The discovery of the Lower Permian fossil wings enables us to understand what has been the primary dichotomy in the venation, and a new subdivision based on venational, antennal and prothoracic characters is here offered:—

Antennae with from 15 to 47 segments (very rarely 14 in one or two Atropidae); forewing with Cu_2 and $1A$ diverging, usually strongly so; prothorax large. Suborder PARAPSOCIDA

Antennae with 13 segments (rarely 14 or 15 in one or two non-Australian species); forewing with Cu_2 and $1A$ converging or meeting apically; prothorax small. Suborder EUPSOCIDA

Suborder PARAPSOCIDA

This Suborder has the tarsi always 3-segmented, the wings held more flatly arched than in the Eupsocida, the venation highly aberrant, but retaining the primitive

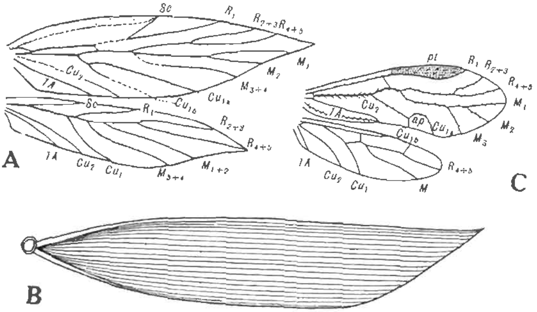

FIG. N2. A. *Oxypsocus hamiltoni* Till., New Zealand. Fam. Lepidopsocidae. Wings descaled. Lettering as in fig. A8, p. 22. B, a single scale from same (× 830). C, *Caecilius flavistigma* Till., New Zealand. Fam. Caeciliidae. Wings. [R. J. T. del.

character of Cu_2 diverging from *1A*. Forms with the wings reduced or absent are common. The four families represented in our region may be separated as follows:—

1. Wings present. 2
   Wings absent or vestigial. 3
2. Wings usually of normal size, pointed, with complete venation, the veins and abdomen clothed with asymmetrical scales. Fam. 1. LEPIDOPSOCIDAE
   Wings reduced, well rounded, hardened or tegminized, with incomplete venation; scales absent. Fam. 2. PSOQUILLIDAE
3. Meso- and metathorax separate. Fam. 3. ATROPIDAE
   Meso- and metathorax completely fused together. Fam. 4. TROCTIDAE

Family 1. **Lepidopsocidae** [Aus. 1, N.Z. 2]. The very rare, archaic forms belonging to this small family are represented by *Echmepteryx hartmeyeri* End. from Western Australia, *Oxypsocus hamiltoni* Till. (fig. N2, A, B) and an undescribed species from New Zealand. In life, these little insects resemble small moths, the scaly covering being particularly deceptive.

Family 2. **Psoquillidae** [Aus. 0, N.Z. 1]. A fine species of this rare family occur in New Zealand, but has not yet been described; it has small, hard, black and almost circular forewings.

Family 3. **Atropidae** [Aus. 1, N.Z. 0]. Apart from the Western Australian *Hyperetes australicus* End., this family is only represented by the world-wide, introduced book-lice *Atropos pulsatoria* Müll. and *Lepinotus inquilinus* Heyd., destructive pests of libraries and museums; both grow to well over 1 mm. in length.

Family 4. **Troctidae**. The only representative is the tiny book-louse or cabinet-mite, *Troctes divinatorius* L.; it is the smallest known species of the Order, seldom exceeding 1 mm. in length when mature.

Suborder EUPSOCIDA

Tarsi 2- or 3-segmented; wings usually held at a steep angle roof-wise, over the abdomen; venation typical (reduced in a few forms), with Cu_2 and *1A* of fore-

wing strongly converging or meeting distally; apex of forewing nearly always well rounded. The archaic Amphientomidae and the large, highly specialized *Thyrsophoridae are not represented in our fauna; the four remaining families may* be distinguished as follows:—

1. Tarsi 3-segmented. 2
   Tarsi 2-segmented. 3
2. Forewing with cubital loop (Cu_{1a}) not touching *M* above it. Fam. 5. MESOPSOCIDAE
   Forewing with cubital loop either touching *M* or fusing with it for a short distance. Fam. 6. MYOPSOCIDAE
3. Forewing with cubital loop not touching *M* above it, or entirely absent. Fam. 7. CAECILIIDAE
   Forewing with cubital loop either touching *M*, or fused with it for a short distance Fam. 8. PSOCIDAE

Family 5. **Mesopsocidae** [Aus. 2, N.Z. 5] Very small species mostly prettily marked, with hairy venation resembling that of the Caeciliidae, but distinguished by their 3-segmented tarsi. The genus *Philotarsus*, in which most of the species are darkly spotted or speckled, occurs in both countries. *Zelandopsocus formosellus* Till. (pl. 2, fig. 7) is a very beautiful New Zealand species. The Australian *Tricladus froggatti* End. is peculiar in having Cu_{1a} of *forewing connected with M by a strong cross-vein.*

Family 6. **Myopsocidae** [Aus. 4, N.Z. 1]. This family contains larger species with venation much resembling that of the Psocidae. The genus *Myopsocus* is represented by three closely allied, mottled greyish or brownish species, *M. australis* Br. and *M. griseipennis* McL. in Australia, *M. novae-zelandiae* Kolbe. (pl. 2, fig. 6) in New Zealand; their larvae are commonly found in colonies under the bark of forest trees, busily engaged in gouging out the dry bark-dust on which they feed. *Propsocus* and *Pentacladus* are rare Australian genera, the latter peculiar in having *M* 5-branched in forewing.

Family 7. **Caeciliidae** [Aus. 14, N.Z. 9]. This family is well represented in both countries by a number of small species, mostly inconspicuously coloured and having the wing-veins hairy. The world-wide genus *Caecilius* includes a number of dainty species of pale yellowish or brownish colour, one of the commonest being the New Zealand *C. flavistigma* Till. (fig. N2, C). The two Australian species of *Cladioneura* are very beautiful insects found on Eucalypts. The subfamily Peripsocinae, in which the cubital loop is entirely absent, is represented by the genera *Peripsocopsis*, *Ectopsocus* and allies. The tiny *E. congener* Till., common in gardens and orchards in New Zealand, feeds on fungal growths on leaves. The allied *E. briggsi* McL., originally described from a Devonshire greenhouse, has been traced back to Sydney, and is probably common in Australia. In this genus the wings are held in a flat arch over the back.

Family 8. **Psocidae** [Aus. 10, N.Z. 0]. This family, dominant in most parts of the world, contains fairly large species up to half-an-inch or more in expanse, easily recognized by the form of Cu_{1a} in forewing, and the 2-segmented tarsi. Several fine species of *Psocus* occur in Australia, while the allied *Clematostigma, Amphigerontia, Lasiopsocus* and *Stenopsocus* are represented by a single species apiece. The handsome *A. formosa* Bks. (pl. 11, fig. 6) is the largest member of the Order known in Australia, expanding up to 15 mm.; it occurs in South Queensland.

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CHAPTER XVII

Order ANOPLURA

(Including MALLOPHAGA)

(Lice)

As here constituted, this Order contains both the Biting Lice (Suborder Mallophaga) and the Sucking Lice (Suborder Siphunculata). Though in most textbooks these two groups are dealt with as separate Orders, the name Anoplura being confined to the Sucking Lice, yet we consider, following L. Harrison, that the differences are not sufficient to warrant their retention. The general facies and morphology of the two groups are closely similar, the chief difference being in the mouth-parts, which are complete and mandibulate in the Mallophaga, but aborted in the blood-sucking Siphunculata, in which the piercing organs are formed as chitinizations of the hypopharynx. A progressive amalgamation of the segments of the thorax is also to be seen in the group, the Amblycerous Mallophaga having all three segments free, the Ischnocerous Mallophaga having meso- and metathorax joined together, and the Siphunculata having all three segments fused into a single whole. The Siphunculata appear to be a specialization from the base of the Ischnocerous stem, but the Amblycera stand well apart from them. The whole Order appears to be a highly specialized derivative from the base of the Copeognathous stem.

The Insects comprised in this Order, known collectively as *lice*, are all parasitic on mammals and birds, and can be at once recognised by their small size, dorso-ventral flattening and absence of wings.

Characters. Small, dorso-ventrally flattened insects, more or less oval in shape, armed with rows of hairs or spines, more rarely with scales.

Head usually large in Mallophaga, small in Siphunculata, often widened posteriorly; *compound eyes* either small and pigmented, or absent; *ocelli* absent; *antennae* typically 5-segmented, sometimes reduced to 4 or 3 segments. *Mouth-parts* in the Mallophaga of reduced size, not projecting from the head-capsule, but typically mandibulate in form; *mandibles* present, with a sharp apical tooth; *maxillae* either with a definite palp with four segments or less, or without palp; *labium* much reduced, without palps. In the Siphunculata, the mandibles, maxillae and both pairs of palpi are absent, the sucking organs consisting of a *dorsal* and *ventral stylet* for piercing, enclosed in a sheath; these organs are not homologous with those of the Hemiptera, but are chitinizations of the hypopharynx.

Thorax either with all three segments free (Amblycera) or with *meso-* and *metathorax* fused together, leaving the *prothorax* free (Ischnocera) or with all three segments fused into a single greatly flattened piece (Siphunculata). *Spiracles* one pair only, placed dorsally on the prothorax. *Legs* short and strong, formed for running or clinging; coxae, femora and tibiae all short, the tarsi with one or two segments, and ending in one or two strong claws. *Wings* entirely absent.

Abdomen flattened, narrowly to broadly oval, with nine visible segments; *cerci* absent. *Spiracles* usually six pairs, situated on segments 3-8 or 2-7; rarely only five pairs. Males with chitinized penis and well developed parameres. Females with broad subgenital plate (eighth sternite) and sometimes with a pair of gonapophyses.

Life History. The *eggs* are rather elongate oval, and are cemented to the hair or feathers of the host (in the case of man, sometimes to his clothes). The *larvae* closely resemble the adults in form; there are four instars, and the metamorphosis is very slight. The whole life is spent upon the body of the host. When the host dies, the lice either continue clinging to it and soon perish, or they leave it and die unless they succeed in finding a new host very soon. Most forms live only on one species of host or on a few closely related species; a few only are found on many hosts.

Distribution. Since practically every bird and marsupial has one or more Mallophagan parasites, the number of species to be found in Australia and New Zealand must be considerable The Siphunculta being confined to Eutherian Mammals, few species can be expected, and those only on native rodents or on the marine mammals around our coasts. At present, 88 native species are recorded for Australia, all but four of these being Mallophaga; thirty species of Mallophaga are known from New Zealand and twelve from the Kermadec Islands. Introduced species are numerous, totalling 34 Mallophaga and 14 Siphunculata.

Fossil History. No fossils of this Order are known.

Economics. All the species being parasites of mammals or birds may be classed as potentially injurious, but only the introduced species are really of economic importance. Of these, the most important belong to the Siphunculata, parasitizing man and his domestic animals, the dog, horse, ox, sheep, camel and pig. A heavy infestation sometimes leads to great suffering and even to the death of the host. Other introduced species of sucking lice live on the rabbit and rat, but are of no value in checking these pests. The only Mallophaga of economic importance are the introduced species which live on poultry, the young birds especially suffering very severely sometimes from the irritation caused to the skin by their attacks. The dust-bath is a fowl's natural protection against them.

CLASSIFICATION.

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order ANOPLURA* 88 (54)

Suborder	Division	Family
Suborder MALLOPHAGA 84 (42)	Division *ISCHNOCERA* 55 (28)	1. Menopidae 16 (14)
		2. Boopiidae 13 (0)
		3. Gyropidae
	Division *AMBLYCERA* 29 (14)	4. Philopteridae 55 (28)
		5. Trichodectidae
Suborder SIPHUNCULATA		6. Echinophthiriidae 3 (3)
		7. Haematopinidae 1 (0)
		8. Pediculidae

*The New Zealand census includes the Kermadec Is. species.

The Order is divisible into two well-marked Suborders as follows:—

Species with complete mandibulate mouth-parts feeding on the feathers or detritus of the skin of the host; prothorax free. (Biting lice, bird lice). Suborder MALLOPHAGA

Species with mouth-parts absent, but having a dorsal and ventral stylet developed from the hypopharynx; feeding by piercing the skin and sucking the blood of the host; all three segments of thorax fused into a single whole (Sucking lice). Suborder SIPHUNCULATA

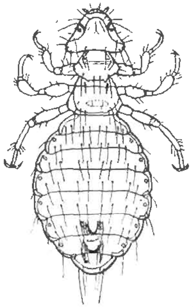

FIG. O1. *Boopia notafusca* Le Souef. Australia, male. Fam. Boopidae; host, *Macropus ualabatus*. Length 1.8 mm. [*After L. Harrison.*

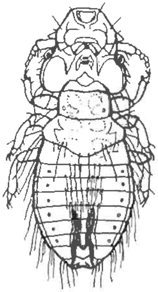

FIG. O2. *Aptericola gadowi* Harr., New Zealand, male. Fam. Philopteridae; host, *Apteryx australis*. Length 1.8 mm. [*After L. Harrison.*

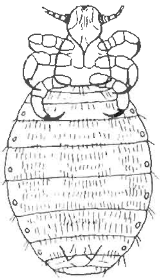

FIG. O3. *Linognathus pedalis* Osb., male, the introduced foot-louse of the sheep. Fam. Haematopinidae. Length 1.9 mm. [*R. J. T. del.*

Suborder MALLOPHAGA

(Biting Lice, Bird Lice).

Most of the species parasitize birds or marsupials; a few introduced species occur on Eutherian mammals. The Suborder falls naturally into two well-marked groups of higher than superfamily value, as follows:—

Antennae with 4-5 segments, the last more or less clubbed, and the whole concealed in a groove (antennary fossa) beneath the head; mandibles placed horizontally; maxillary palpi present, with 4-5 segments; meso- and metathorax nearly always distinct. Division *AMBLYCERA*

Antennae with either 5 or 3 segments, filiform, not concealed; mandibles placed vertically; maxillary palpi absent; meso- and metothorax always fused together. Division *ISCHNOCERA*

Division *AMBLYCERA*

This Division is the more primitive in the form of the mandibles and maxillae, and in the free condition of the thoracic segments, but the structure of the antennae is highly specialized. Three families are represented in our fauna, but one of these, the Gyropidae, only contains introduced species; they may be separated as follows:—

1. Tarsi with only a single functional claw; parasitic on introduced rodents only. Fam. 3. GYROPIDAE
   Tarsi with two functional claws. 2
2. Antennae with 5 segments; hairs of the body mostly in the form of

stiff, slender spines; male genitalia with a large accessory sac; parasitic on marsupials. Fam. 2. BOOPIIDAE

Antennae with 4 segments; hairs of the body very soft; no accessory sac present in males. Fam. 1. MENOPIDAE

Family 1. **Menopidae** [Aus. 16, N.Z. 14]. The best known genera are *Menopon* and *Colpocephalum*, each with six native species in Australia, six and three respectively in New Zealand. There are seven introduced species, of which six belong to *Menopon*; *M. gallinae* L. (=*M. pallidum* Nitzsch) is the common chicken-louse.

Family 2. **Boöpiidae** [Aus. 13, N.Z. 0]. This family, parasitic on marsupials, is confined to Australia, so far as at present known. The principal genera are *Boöpia*, *Heterodoxus*, *Paraheterodoxus* and *Laticephalum**; the first-named contains eight species having 4-segmented palpi and found on kangaroos and wallabies. *Boopia notafusca* Le Souef (fig. O1) is one of the best known species. The two species of *Laticephalum* also occur on kangaroos and wallabies, but have only 2-segmented palpi.

Family 3. **Gyropidae.** Two introduced species are recorded from Australia, viz., *Gyropus ovalis* Nitzsch and *Gliricola porcelli* L.; both are found on the guinea-pig.

Division *ISCHNOCERA*

Although the antennae of this group are of more primitive form than those of the Amblycera, yet they must be regarded as on the whole more highly specialized than the latter on account of the complete fusion of meso- and metathorax, and the absence of maxillary palpi. The two families represented in our fauna (one by introduced species only) may be distinguished as follows:—

Antennae with 5 segments; tarsi with two claws; parasitic on birds. Fam. 4. PHILOPTERIDAE

Antennae with only 3 segments; tarsi with a single claw; parasitic on Eutherian mammals. Fam. 5. TRICHODECTIDAE

Family 4. **Philopteridae** [Aus. 55, N.Z. 28]. The genera *Goniodes*, *Lipeurus*, *Degeeriella* and *Philopterus* are well represented in Australia; species of the first two genera have been found on the native companion, ibis, black swan, wild geese and allied birds, while those of the two last-named occur on the lyre-bird, laughing jackass and cockatoos. The only louse so far found on penguins belongs, curiously enough, to the genus *Austrogoniodes*, a close relative of *Goniodes*, which is chiefly found on gallinaceous birds. The interesting genus *Aptericola* is confined to the species of New Zealand Kiwi (*Apteryx*); the commonest species is *A. gadowi* Harr. (fig. O2) from *Apteryx australis*. This genus is a close relative of *Rallicola*, found exclusively on Rails. L. Harrison has claimed that this indicates a probable Rallid affinity for the Kiwi, a conclusion which is borne out by certain points in its anatomy also. There are twenty introduced species, mostly belonging to *Goniodes* and *Lipeurus*, parasitic on poultry.

Family 5. **Trichodectidae**. This family is only represented by five introduced species of *Trichodectes* found on domestic animals, viz., *T. pilosus* Gieb. on the horse, *T. bovis* L. on cattle, *T. ovis* L. on sheep, *T. climax* Nitzsch on goats, and *T. subrostratus* Nitzsch on cats.

Suborder SIPHUNCULATA

(Sucking Lice).

The three families in our fauna (one containing introduced species only) can be distinguished as follows:—

1. Body clothed with spines and scales, or only with short, stout spines; parasites of marine mammals only. Fam. 6. ECHINOPHTHIRIIDAE

   Body clothed with definite rows of hairs or slender spines; parasites of land mammals only. 2

2. Eyes absent, not parasitic on man or monkeys. Fam. 7. HAEMATOPINIDAE

   Eyes present; parasitic only on man and monkeys. Fam. 8. PEDICULIDAE

Family 6. **Echinophthiriidae** [Aus. 3, N.Z. 3]. The three species recorded

*Altered with the author's consent from *Latumcephalum* Le Souef, which is not a grammatical form.

from marine mammals in Australian and New Zealand waters all belong to the subfamily Antarctophthirinae, in which the body is clothed with scales. *Antarctophthirus microchir* Tr. & Neum., occurs on the Sea-lion (*Arctocephalus hookeri*) at Auckland Islands, *A. ogmorhini* End. on the Sea-leopard (*Ogmorhinus*) in the Antarctic, and *Lepidophthirus macrorhini* End. on the Sea-elephant (*Macrorhinus*) at Kerguelen Island.

Family 7. **Haematopinidae** [Aus. 1, N.Z. 0]. The only native species is *Polyplax bidentatus* Neum. from the Australian water-rat (*Hydromys chrysogaster*). Common introduced species found in both countries in connection with domestic animals are the following:—*Linognathus piliferus* Burm. on dogs; *L. vituli* L. and *Haematopinus eurysternus* Nitzsch on cattle; *Linognathus ovillus* Neum. and *L. pedalis* Osb. (fig. O3) on sheep, the former infesting the body, the latter the legs and feet; *Haematopinus suis* L. on swine; *H. asini* on horses and donkeys; *H. tuberculatus* Burm. on camels and buffalo; and *Haemodipsus ventricosus* Denny on rabbits.

Family 8. **Pediculidae**. Four species of this family have been introduced into Australia and New Zealand, but one of these, *Pedicinus eurygaster* Burm. only occurs on monkeys in zoological gardens. The other three are well-known parasites of man, viz., the head-louse, *Pediculus capitis* L., the body-louse, *P. vestimenti* Nitzsch, and the crab-louse, *Phthirus pubis* L.

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CHAPTER XVIII

Order THYSANOPTERA

(Thrips)

The small, elongate insects comprised in this Order, commonly called Thrips, infest the buds, blossoms, leaves and roots of plants. They are

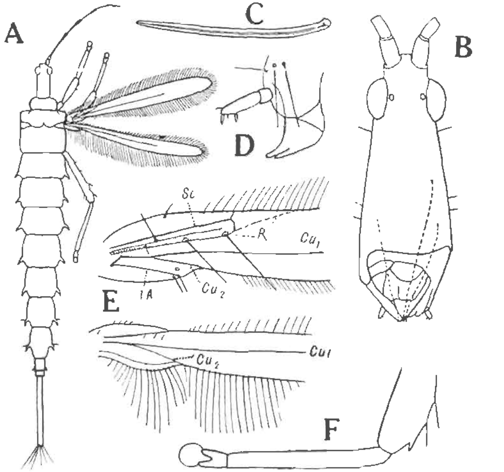

FIG. P1. A, *Idolothrips spectrum* Hal., female. Australia. Fam. Phloeothripidae. Length 12 mm. B, head of same, enlarged, ventral view, showing the anteriorly situated antennae, eyes and two ocelli, and the posteriorly situated mouth-parts: the dotted *lines indicate the positions of the three stylets.* C, *left mandibular* stylet, enlarged, showing groove. D, right maxilla with two-segmented palp, enlarged. E, bases of wings, enlarged, to show venation and setae. F, tarsus and end of tibia of foreleg, enlarged, showing the terminal bladder inflated. [*R. J. T. del.*

easily recognized by the very short, slender wings, bordered with long fringes, with scarcely any venation, and by the peculiar bladder-like organ situated at the end of the tarsi.

Characters. H e a d (fig. P1, B) strongly chitinized, short or elongate; *compound eyes* usually present; *ocelli* (two or three) present in the winged forms only; *antennae* with 6-10 segments, arising close together from the top of the head. *Mouth-parts* asymmetrical, projecting backwards so as partially to overlap the prosternum; *labrum* quite asymmetrical, forming the upper part of a conical sheath through which the *stylets* project. These stylets are three in number, and are formed from the mandibles and maxillae, but their homologies appear to differ in the two Suborders. In the Tubulifera (fig. P1), the right *mandible* is aborted; the longest and stoutest stylet is formed from the left *mandible* (fig. P1, C), while the two shorter and slenderer stylets are formed from parts of the two *maxillae*, probably the laciniae. In the Terebrantia, on the other hand, there are two mandibular stylets and only one maxillary, that of the right maxilla being absent. The other portions of the two *maxillae* (fig. P1, D) are asymmetrically shaped, with broad bases, short palpi with 2-3 segments, and in inner lobe (probably the galea) which is pointed and more or less bent; in the Terebrantia, these portions of the two maxillae differ greatly in shape, but in the Tubulifera they are more or less similar. *Labium* broad and short, forming the lower portion of the sheath for the stylets, and consisting of a broad mentum, a narrower portion carrying two very short, 2-4 segmented palpi, and a tiny ligula with two minute processes, probably the paraglossae. The stylets work through the apical orifice of the sheath, and are used to pierce, rasp or lacerate the tissues of plants.

T h o r a x with *prothorax* generally well developed, *meso-* and *metathorax* short and broad, more or less fused together. *Legs* with short coxae, stout femora and slender tibiae without spurs; tarsi (fig. P1, F) with only one or two segments, usually ending in a bladder-like organ*; in gall-forming species, the fore tarsi may be aborted, the tibia ending in two stout claws suitable for burrowing. *Spiracles* two pairs.

W i n g s either absent or four in number, both pairs being exceedingly narrow and not reaching to end of abdomen, over which they are folded flatly; hindwing slightly narrower and shorter than fore; both wings provided with a long and abundant fringe of fine hairs. *Venation* at most consisting of two longitudinal veins, *R* and Cu_1, sometimes with the reduced remains of other veins near the base (fig. P1, E). A definite but very small anal area is usually present, bounded anteriorly by a short Cu_2.

A b d o m e n elongate, subcylindrical, narrow, tapering posteriorly, with ten complete segments but no cerci; male and female genitalia variable, the female with or without an ovipositor. *Spiracles* eight pairs, on segments 1-8. *Malpighian tubules* four.

Life History. The *eggs* are elongate, either laid externally or inserted into the tissues of the host-plant by means of the ovipositor. The *larvae* closely resemble the imago, but have all three thoracic segments free; there are from two to four larval instars, followed by one or two resting-stages in which the insect hides away and takes no food; there is no marked metamorphosis, the imaginal condition differing only by the attainment of sexual maturity and the appearance

*From this character is derived the alternative ordinal name, Physapoda, now seldom used.

of wings in those species which possess them. Usually more than one generation occurs in a year, the rate of increase being markedly greater during hot, dry weather, when parthenogenesis takes the place of sexual reproduction. Males are always much rarer than females. The Tubulifera feed mostly on dead leaves, fungi, etc.; in the gall-forming species, the eggs are laid inside the gall by the insect inhabiting it, and the whole brood of young larvae develop inside it. Most of the Terebrantia feed on the tissues of living plants.

Distribution. Australia contains one of the most abundant Thrips fauna in the world, and possesses the largest and most peculiar of the species; the total number of native species known is over seventy. The interesting gall-forming species are confined to the dry inland parts of the continent. No native species are known in New Zealand.

Economics. The native species of Thysanoptera do little or no economic damage, even the gall-making species being of no importance in this respect. Unfortunately a dozen introduced species abound on garden plants, vegetables, fruit trees and cereals, and at times do a great deal of damage, especially during hot, dry weather.

Fossil History. The only fossil records of this Order are from the Oligocene beds of Europe and North America, including several species found in Baltic Amber.

CLASSIFICATION.

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order THYSANOPTERA 72 (0)

Suborder TEREBRANTIA 18 (10)	1. AEOLOTHRIPIDAE 1 (0) 2. THRIPIDAE 17 (0)
Suborder TUBULIFERA 54 (0)	3. PHLOEOTHRIPIDAE 54 (0)

The Order, though a very small one, falls naturally into two well-marked Suborders as follows:—

Last segment of abdomen conical, that of the male well rounded; female with a saw-like ovipositor. Wings with at least one longitudinal vein reaching from base to apex. Suborder TEREBRANTIA

Last segment of abdomen elongated and tubular in both sexes. Wings with only one longitudinal vein, which does not reach as far as the apex. Suborder TUBULIFERA

Suborder TEREBRANTIA

The two families comprising this Suborder are distinguished as follows:—

Antennae with 9 segments; forewing comparatively broad, with well rounded apex and well developed veins; ovipositor of female curved upwards. Fam. 1. AEOLOTHRIPIDAE

Antennae with from 6 to 10 segments; wings narrow and rather pointed at their apices; ovipositor of female curved downwards. Fam. 2. THRIPIDAE

Family 1. **Aeolothripidae** *(Aus. 1, N.Z. 0). The only Australian species* of this family is *Rhipidothrips cinctus* Hood from North Queensland. This genus is otherwise only known from Europe.

Family 2. **Thripidae** [Aus. 17, N.Z. 0]. The Australian representatives of this family are mostly rare species belonging to a number of well-known genera, including *Heliothrips* and *Frankliniella*.

This family contains all the introduced species, a dozen in number; the most important of these are the Wheat Thrips, *Frankliniella tritici* Fitch., the Onion Thrips, *Thrips tabaci* Lind., the Black Fly or Greenhouse Thrips, *Heliothrips haemorrhoidalis* Bouché, the Grass Thrips, *Anaphothrips striatus* Osb., and *Euthrips nervosus* Uzel; the last-named occurs on roses around Melbourne. The Wheat Thrips damages fruit trees and strawberries as well as wheat; the Onion Thrips destroys the buds and blossoms of roses and other garden plants, as well as attacking the bulbs and leaf-axils of onions; the Grass Thrips frequently damages oats as well as various introduced grasses.

Suborder TUBULIFERA

This Suborder contains only one family, which has its headquarters in Australia.

Family 3. **Phloeothripidae** [Aus. 54, N.Z. 0]. The commonest and also the largest of all the Australian species is *Idolothrips spectrum* Hal., the Giant Thrips (fig. P1), mature specimens of which have been taken up to half-an-inch in length. The types were captured by Charles Darwin in 1836. This sluggish insect, dark brown or black in colour, can be found in large numbers, especially in the spring, by shaking dead eucalyptus foliage lying on the ground. Numerous smaller species are known belonging to the genera *Phloeothrips, Haplothrips, Liothrips, Cryptothrips and Cladothrips*. *Ph. tepperi* Uzel forms galls on the Mulga (*Acacia aneura*). The genus *Cladothrips* has the forelegs ending in strong burrowing claws.

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CHAPTER XIX

Order HEMIPTERA

(or RHYNCHOTA)

(Cicadae, Plant Hoppers, Plant Lice, Scale Insects, Bugs)

THIS Order is a very extensive one, comprising a great number of insects of very diverse appearance, but for the most part plant-feeders. The character which unites them all is the sucking beak, attached to the underside of the head and projecting backwards in the position of rest.

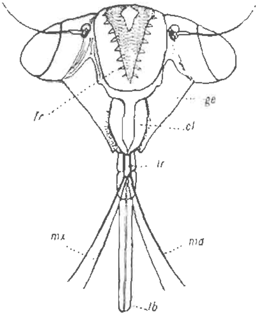


FIG. 91. Head and mouth-parts of a Cicada, *Melampsalta cingulata* Fabr., New Zealand; *cl*, clypeus; *fr*, frons; *ge*, gena; *lb*, labium; *lr*, labrum; *ma*, mandible; *mx*, maxilla. [*A. Tonnoir del.*

Characters. Head very variable in shape and size; *compound eyes* always present, never touching; *ocelli* either 3, 2, or absent; *antennae* normally with 3-5 segments only, rarely with more (up to 25). *Mouth-parts* forming a sucking beak, the *mandibles* and *maxillae* specialized as two pairs of long, slender piercing organs, the outer pair being the mandibles, the inner the maxillae; maxillary palpi entirely absent. These piercing organs are enclosed in a segmented sheath, formed from the *labium*, normally with four segments, but sometimes reduced to three or less. *Labrum* comparatively short, covering the base of beak in front, and more or less pointed. In the process of sucking, only the two pairs of stylets play a part, the sheath not being inserted into the wound, but doubled back at one of its joints. The mandibles are barbed

Plate 11

AUSTRALIAN INSECTS OF VARIOUS ORDERS

All figures natural size except figs. 6 and 18

Order ODONATA

1. *Diphlebia euphoeoides* Till. (Fam. AMPHIPTERYGIDAE), male
2. *Austropetalia patricia* Till. (Fam. AESCHNIDAE), female.
3. *Rhyothemis graphiptera* Sel. (Fam. LIBELLULIDAE), male.
4. *Rhyothemis resplendens* Sel. (Fam. LIBELLULIDAE), male.

Order PERLARIA

5. *Eusthenia lacustris* Till. (Fam. EUSTHENIIDAE).

Order COPEOGNATHA

6. *Amphigerontia formosa* Bks. (Fam. PSOCIDAE), (x 1.3).

Order HEMIPTERA

7. *Catacanthus nigripes* Stal. (Fam. PENTATOMIDAE).
8. *Agonoscelis rutila* Fabr. (Fam. PENTATOMIDAE).
9. *Cantao parentum* F.B.W. (Fam. PENTATOMIDAE).
10. *Havinthus rufovarius* Berg. (Fam. REDUVIIDAE).
12. *Thopha sessiliba* Dist. (Fam. CICADIDAE).
12. *Thopa sessiliba* Dist. (Fam. CICADIDAE).
13. *Eurymela rubrovittata* A. & S. (Fam. JASSIDAE).
14. *Eufairmairea fraterna* Dist. (Fam. MEMBRACIDAE).
15. *Desudaba maculata* Dist. (Fam. FULGORIDAE).
16. *Platybrachys decisa* Walk. (Fam. EURYBRACHIDAE).
17. *Achilus flammeus* Kby. (Fam. ACHILIDAE).
18. *Creiis longipennis* Walk. (Fam. PSYLLIDAE), (x 1.3).

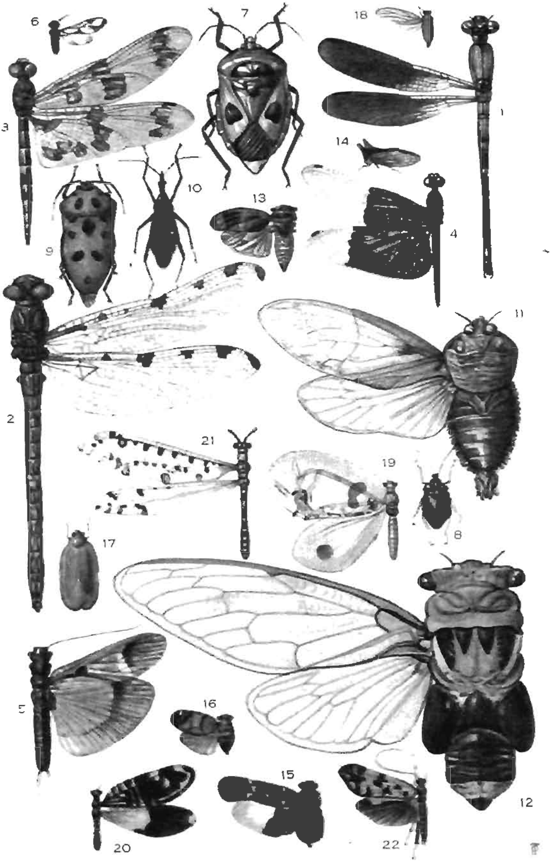
Order NEUROPTERA

19. *Psychopsis elegans* Guer. (Fam. PSYCHOPSIDAE).
20. *Porismus strigatus* Burm. (Fam. OSMYLIDAE).
21. *Periclystus aureolatus* Till. (Fam. MYRMELEONTIDAE).

Order TRICHOPTERA

22. *Stenopsychodes melanochrysa* Till. (Fam. POLYCENTROPODIDAE).

Plate II



F. Tillyard pinx.

AUSTRALIAN INSECTS OF VARIOUS ORDERS

at their tips to give a strong hold. The sucking action is carried out by means of a strong *pharyngeal pump*, and there is also a syringe or *salivary pump* which forces the saliva into the beak for injection into the wound. Embryology shows that the maxillary stylets are developed by elongation of the stipes, the cardo forming the maxillary plate at the side of the head. Nothing is known as to the fate of the maxillary palpi; the labial palpi also appear to be absent except in the Belostomatidae, where they may be represented by two small, articulated processes at the base of the beak.

T h o r a x with all three segments generally well developed, the *prothorax* often large; *mesothorax* with a well developed scutellum, sometimes greatly enlarged. Meso- and metapleuron sometimes each composed of a single plate, sometimes of several. *Legs* very variable, formed for walking, running, swimming or grasping; tibiae usually without spurs; tarsi normally with 3 segments, sometimes reduced to 2 or 1. *Spiracles* two pairs; the spiracles of the first abdominal segment also sometimes appear to belong to the metathorax.

W i n g s either held roof-wise over the back, or folded back flatly over the body with the distal portions overlapping and coinciding. *Forewing* generally of tougher texture than hind, forming a *tegmen*, usually with the venation remaining distinct upon it. In nearly all Heteroptera, however, it becomes further specialized by a transverse division marking off a basal, hardened, coriaceous portion, called the *corium*, on which the venation is faint or absent, and a distal, softer, membranous part, called the *membrane*, on which the venation remains present. In both Suborders the anal area of the forewing is strongly separated off (except in a few very reduced forms) as a distinct *clavus* bounded anteriorly by the *vena dividens* (Cu_2) in a deep groove called the *claval suture*. *Wing-venation* very variable, but usually with a certain amount of fusion basally between the main veins; *M* normally with three or four branches, Cu_1 normally with a distal fork. *Hindwing* entirely membranous, usually with a folded anal area of small size.

A b d o m e n normally with ten segments in Heteroptera, eleven in many Homoptera; anal opening with a terminal *anal style* sometimes projecting below it. *Cerci* always absent. *Spiracles* normally eight pairs, on segs. 1-8, but the first two pairs are sometimes obscure, as are also the segments bearing them. The males have well developed genitalia, seg. 9 forming a ring-like *pygophor* produced ventrally into a pair of flat processes, the *genital plates* (sometimes fused together or reduced in size); above these, just below the base of the aedeagus, is a pair of *genital styles*, representing the gonocoxites of seg. 9. *Aedeagus* consisting of a tubular *penis* retractile into a sheath and often furnished with a pair of hooks (*penunci*) near its apex; *parameres* sometimes present, making the aedeagus trilobed. In Cicadidae the eighth sternite forms a broad *hypandrium* covering the pygophor from below. The females of the more archaic families have a fairly complete *ovipositor* formed from three pairs of gonapophyses but of somewhat specialized type; the ventral valves have their outer basal angles joined to those of the ninth tergite; the inner valves form a median bifid process grooved on its ventral side; and the dorsal valves form, as usual, a sheath for the rest of the organ. The above details refer more especially to the Homoptera; the Heteroptera in general are more highly specialized.

and the males are peculiar in having the tenth segment flattened, membranous beneath, and forming a protecting cover for the aedeagus, the pygophor in the form of a wide terminal chamber, the penis often very slender and greatly elongated, and the eighth segment much reduced in size. *Malpighian tubules* usually two only (one in Coccidae, none in Aphididae).

Life History. The *eggs* are laid upon or in the tissues of plants, singly or in masses. The *larvae* are similar to the adult in form, and usually have similar habits; only in those cases where their habits are different, as in the burrowing larvae of Cicadas (fig. Q21), do they show any appreciable difference of form from the imago. There are normally six instars, including the imago (fig. A20), but the number may be less in some specialized forms; in one or two cases, eight instars are known. The wings develop externally as backwardly projecting flaps, the forewings overlying the hind. In most cases the metamorphosis is slight, but in many of the Homoptera it is considerable (Cicadas, Cercopids) and in Aleurodidae and the males of Coccidae the last larval instar closely resembles the resting pupa of the Endopterygota.

Distribution. The Order is well represented in Australia by nearly 2000 species, including all except one or two small families; the most abundant groups are the Pentatomidae (370), Coccidae (330), and Cicadidae (180). New Zealand has only about 300 species, the Heteroptera (65 species) being singularly poorly represented; the most abundant family is the Coccidae (114). The faunas of both countries not having been well worked in this Order, many more species remain to be described. Kirkaldy's estimate of 750 Hemiptera for New Zealand will probably one day be exceeded.

Economics. The Order is almost entirely harmful to mankind, the whole of the Homoptera and the great majority of the Heteroptera being plant-feeders, and taking enormous toll of man's vegetable foods. The only beneficial groups are the Reduviidae and Nabidae, which feed on insects, a few Pentatomidae and Capsidae with similar habits, and the Notonectidae and Corixidae which attack mosquito and other aquatic insect larvae. The Scale Insects, Plant Lice, Plant Hoppers and many plant-feeding Bugs are responsible for the greater part of the total damage to our crops and fruit, while some Cicadas damage trees, and the Bed-bug is a well known parasite of man himself.

Fossil History. The earliest undoubted fossil records of this Order lie in the Lower Permian* of Kansas and consist of Homoptera only; both Auchenorrhyncha and Sternorrhyncha were already present. Three genera and four species are known, and all of them agree in having Cu_1 distally forked, M three-branched and R also three-branched. The branches of R come off separately from the main stem, the upper branch being convex and the lower concave; this indicates that the correct notation for the three branches should be R_{1a}, R_{1b} and Rs; but, pending the completion of this research, we have adhered to Comstock's notation of R_1, R_{2+3} and R_{4+5} in the figures of Homoptera given herewith. In the Upper Permian of Belmont, N.S.W., both Auchenorrhyncha and Sternorrhyncha were also represented, the

*Lameere claims that one of the Upper Carboniferous insects of Commentry, France, is a true Homopteron.

Auchenorrhynchous family Scytinopteridae being dominant. In the Upper Trias of Ipswich, Q., the Order is dominant, the Heteroptera being represented by one extinct family of Gymnocerata (Dunstaniidae) and one of Cryptocerata (Triassocoridae), while the Homoptera show a great variety of forms both in Cicadoidea and Fulgoroidea, though only one Sternorrhynchous form has so far been found at this epoch. The Cicadas were represented by their ancestors the Mesogereonidae, the Cercopidae and Membracidae by the Scytinopteridae, while the Jassidae were themselves already present. In the Fulgoroidea, the Tropiduchidae and Cixiidae were present, together with the extinct Ipsviciidae, probably the direct ancestors of the existing Tettigometridae (not found in Australia). A fine Ricaniid, *Scolypopites bryani* Till., has been found in the Tertiary of Goodna, S. Queensland.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order HEMIPTERA 1,969 (295)

Suborder HETEROPTERA 854 (65)

Division *GYMNOCERATA* 806 (59)

I. PENTATOMOIDEA 579 (28)
- 1. Lygaeidae 112 (14)
- 2. Pyrrhocoridae 12 (0)
- 3. Coreidae 52 (0)
- 4. Neididae 1 (1)
- 5. Cydnidae 28 (3)
- 6. Pentatomidae 374 (10)

II. ARADOIDEA 17 (3)
- 7. Aradidae 17 (3)

III. REDUVIODEA 127 (8)
- 8. Nabidae 1 (2)
- 9. Reduviidae 124 (4)
- 10. Henicocephalidae 2 (2)

IV. TINGOIDEA 8 (1) (Piesmatidae)
- 11. Tingidae 8 (1)

V. MIROIDEA 61 (14)
- 12. Miridae 55 (10)
- 13. Anthocoridae 6 (4)
- 14. Cimicidae

VI. GERROIDEA 11 (2)
- 15. Hebridae 1 (0)
- 16. Hydrometridae 3 (0)
- 17. Gerridae 7 (2)

VII. SALDOIDEA 3 (3)
- 18. Saldidae 3 (3)

Division *CRYPTOCERATA* 48 (6)

VIII. PELORIDIOIDEA 1 (1)
- 19. Peloridiidae 1 (1)

IX. OCHTEROIDEA 10 (0)
- 20. Ochteridae 1 (0)
- 21. Gelastocoridae 9 (0)

X. NOTONECTOIDEA 23 (2)
- 22. Nepidae 5 (0)
- 23. Naucoridae 3 (0)
- 24. Belostomatidae 4 (0)
- 25. Notonectidae 11 (2)

XI. CORIXOIDEA 14 (3)
- 26. Corixidae 14 (3)

Suborder HOMOPTERA 1,115 (230)

Division *AUCHENORRHYNCHA* 707 (102)

XIII. FULGOROIDEA 247 (26)
- 31. Cixiidae 25 (17)
- 32. Delphacidae 52 (6)
- 33. Tropiduchidae 5 (0)
- 34. Derbidae 30 (1)
- 35. Dictyophoridae 8 (1)
- 36. Fulgoridae 15 (0)
- 37. Eurybrachidae 28 (0)
- 38. Achilidae 14 (1)
- 39. Issidae 20 (0)
- 40. Lophopidae 1 (0)
- 41. Ricaniidae 9 (0)
- 42. Flatidae 40 (0)

XII. CICADOIDEA 450 (76)
- 27. Cicadidae 180 (20)
- 28. Cercopidae 30 (4)
- 29. Jassidae 200 (52)
- 30. Membracidae 40 (0)

Division *STERNORRHYNCHA* 418 (128)

XIV. PSYLLOIDEA 88 (14)
- 43. Psyllidae 80 (6)
- 44. Aphididae 0 (1)
- 45. Aleurodidae 8 (7)

XV. COCCOIDEA 330 (114)
- 46. Coccidae 330 (114)

The Order is divisible into two very distinct Suborders, as follows:-

Gula present, head not inflexed; beak more or less bent at the base and not in line with the head. Forewing almost always in the form of a *hemielytron*, having a tough basal corium and soft distal membrane, separated by a definite transverse line: the two forewings fold flatly over the abdomen so that their distal portions overlap and coincide. Suborder HETEROPTERA

Gula absent or only membranous, so that head is inflexed and touches the fore coxae; beak straight, in line with mid-ventral surface of head. Forewing in the form of a *tegmen*: the two tegmina nearly always held roof-wise over the abdomen. Suborder HOMOPTERA

Suborder HETEROPTERA

(Bugs)

In this Suborder, the *head* is freely movable, with the sucking beak inserted ventrally towards the anterior end of it (except in Peloridiidae), and projecting backwards; the *antennae* may be either short or long, exposed or hidden, but never have more than five segments. The *prothorax* is large and free (except in Corixidae, where it is overlapped by the head). The wings are always folded back flatly upon the abdomen, so that their distal portions lie upon one another, more or less coinciding. The forewing is normally a *hemielytron*, i.e., it is divided into a tougher, coriaceous portion, called the *corium*, and a thinner, membranous distal part called the *membrane*; the *clavus*, or anal area, is also generally hardened, and separated from the corium by the *claval suture* (fig. Q2).

The homologies of the veins in the hemielytron have been much obscured by the interpretation put upon them by Comstock and Needham. These authors appear to have examined only specialized forms, and considered the most anterior trachea in the larval wing to be *C*, the second *Sc*, the third *R* and the fourth *M*; the fifth trachea, lying posterior to the claval suture, is therefore called by them *Cu*. They thus arrive at the extraordinary conclusion that, in this Suborder alone, of all insects, *Cu* lies in the claval area, whereas, in the Suborder Homoptera and in all other Orders, it lies anteriorly to the claval suture! No reason is given for assigning the notation *C* to the first trachea. Handlirsch rightly considered this trachea to be *Sc*, the second trachea *R* (with terminal R_1 usually missing) the third *M*, and the fourth *Cu*. The discovery of the Upper Triassic fossil Heteroptera of the family Dunstaniidae has brought to light a primitive Pentatomoid type of hemielytron in which the missing R_1 is clearly to be seen, thus indicating the correctness of Handlirsch's interpretation, which is further

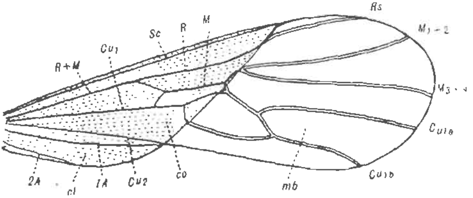


Fig. Q2. Venation of hemielytron of *Lygaeus singularis* Walk., Australia. Fam. Lygaeidae. Lettering as in fig. A8, p. 22; *cl*, clavus; *co*, corium; cu_2, claval suture; *mb*, membrane. [*R. J. T. del.*

strengthened by considerations of the essential unity of structure in the two Suborders Heteroptera and Homoptera. Accepting, therefore, Handlirsch's solution of the problem, the notation of the veins will be as shown in fig. Q2, where a Lygaeid is selected as being very close to the primitive type, though somewhat reduced. *Sc* runs close to, or fuses with, the costal margin; *R* and *M* are fused basally for a greater or less distance (though the tracheae are

separate in the larval wing); Cu_1 stands well in front of the claval suture; Cu_2 is usually absent (probably lost in the claval suture); the clavus has a strong *1A* and sometimes *2A* also. On approaching the membrane, *R*, *M*, and Cu_{1a} all turn upwards, and the dividing line between corium and membrane is formed to a greater or less extent from their bent parts. The veins of the membrane are branches of *Rs*, *M* and Cu_1, R_1 being absent or vestigial in all recent forms. The *hindwing* is membranous with simple venation and a folded anal area. There is little or no branching of the veins, but generally some partial fusions, usually *Sc* and *R* being united at the base, and, distally, *M* connecting with *R*, and *R* with *Sc*.

The *legs* are of variable form, the tarsi normally with three segments, sometimes reduced to two or even one, and occasionally without claws.

Scent-glands (fig. A20) are generally present, opening either on the thoracic pleura or on the surface of the abdomen.

The Suborder falls naturally into two main Divisions, the first of which contains principally terrestrial forms, the second principally aquatic forms:—

Antennae always longer than the head, freely movable in front of it. Division *GYMNOCERATA*

Antennae always shorter than the head, and, except in Ochteridae, concealed beneath it. Division *CRYPTOCERATA*

Division *GYMNOCERATA*

In classifying this Division, the structure of the hemielytron has to be considered in somewhat greater detail than given above. While the division into corium, membrane and clavus holds for a large number of families, there is one group in which a separate hardening of the anterior basal portion of the membrane takes place, beyond the true corium; this piece is triangular or wedge-shaped, and is called the *cuneus* (figs. Q11, 12, *cu*). In addition to this, a longitudinal division of the corium sometimes occurs, separating off a narrowly triangular costal portion, known as the *embolium* (fig. Q12, *em*). The size of the scutellum is of importance, and also the structure of the meso- and metapleuron, these being sometimes formed as a single piece, and sometimes divided up into several pieces.

Australia possesses 18 families of Gymnocerata, all of which occur also in New Zealand except the Coreidae, Hebridae and Hydrometridae. In both countries, the Cimicidae are represented only by the world-wide, introduced Bed Bug. The Division may be separated into six superfamilies, as follows:—

1. Underside of body with silvery, velvety pubescence; aquatic or semi-aquatic forms. VI. GERROIDEA
   Underside of body without such pubescence; terrestrial or riparian forms. 2
2. Meso- and metapleuron each formed of several pieces; hemielytra, when present, with a cuneus. V. MIROIDEA
   Meso- and metapleuron each formed of a single piece; hemielytra without a cuneus. 3
3. Hemielytra with a raised, lace-like reticulation; size very small; tarsi 2-segmented. IV. TINGOIDEA
   Hemielytra without such reticulation; size larger; tarsi variable. 4
4. Beak appressed to underside in repose, and only slightly bent at base, always passing well beyond fore coxae. I. PENTATOMOIDEA
   Beak strongly bent near base, and standing well away from underside in repose, length variable. 5
5. Excessively flat bugs living under bark, the lateral portions of the abdomen extending out beyond the hemielytra; tarsi 2-segmented. II. ARADOIDEA
   Not as above; tarsi 3-segmented (except in Henicocephalidae). 6
6. Head short and broad, with large, prominent eyes; ocelli placed between eyes; beak long. VII. SALDOIDEA
   Head narrow (globular in Henicocephalidae); ocelli placed behind eyes; beak short (except in Nabidae, not reaching beyond fore coxae). III. REDUVIOIDEA

Superfamily I. PENTATOMOIDEA

This large group consists mostly of plant-feeding forms with long, straight beaks always passing backwards between and well beyond the fore coxae; and generally

closely appressed to the underside of the head and prosternum. In the few secondarily carnivorous forms which occur, the beak stands a little out from the head basally, but the distal part is straight and held very similarly to that of the plant-feeding forms. The head is small and subtriangular in shape, its width across the eyes being generally about equal to its total length. Six families occur, distinguished as follows:—

1.	Scutellum not reaching to end of clavus.	2
	Scutellum reaching to end of clavus or beyond	5
2.	Antennae elbowed; legs long and slender.	Fam. 4. NEIDIDAE
	Antennae not elbowed; legs normal.	3
3	Membrane of hemielytron with at most five separate veins.	Fam. 1. LYGAEIDAE
	Membrane of hemielytron with at least six separate veins.	4
4.	Ocelli present.	Fam. 3. COREIDAE
	Ocelli absent.	Fam. 2. PYRRHOCORIDAE
5.	Burrowing forms with thickly spinose hind tibiae.	Fam. 5 CYDNIDAE
	Non-burrowing forms, the hind tibiae not thickly spinose.	Fam. 6. PENTATOMIDAE

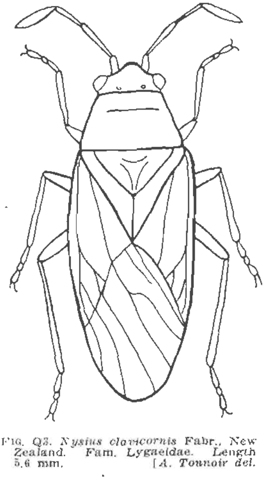


FIG. Q3. *Nysius clavicornis* Fabr., New Zealand. Fam. Lygaeidae. Length 5.6 mm. [*A. Tonnoir del.*

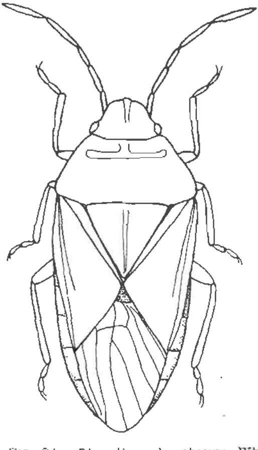


FIG. Q4. *Rhopalimorpha obscura* Wh., New Zealand. Fam. Pentatomidae, subfam. Acanthosomatinae. Length 8.5 mm. [*A. Tonnoir del.*

Family 1. **Lygaeidae (Myodochidae)** [Aus. 112, N.Z. 14]. These bugs, known as Chinch Bugs in America, can be recognized by the reduced venation of the membrane in the hemielytron, there being at most only five separate longitudinal veins; the antennae are usually inserted well below the level of the eyes and the ocelli are nearly always present.

In the subfamily Lygaeinae, which contains the more normally shaped species, the chief genera represented are *Lygaeus*, *Astacops*, *Arocatus*, *Oncopeltus* and *Nysius*. ***Arocatus ruficollis*** Walk (pl. 2, fig. 8) is a handsome grey bug

with red collar, found under bark and in masses of creeper in both countries. The widespread genera *Lygaeus* and *Oncopeltus* contain a few Australian species, *O. sordidus* Dall. being a pest on cotton plants in Queensland. *L. singularis* Walk. (pl. 12, fig. 1) is a rather handsome, reddish species with black membrane and a black spot on each corium. The genus *Nysius* consists of much smaller insects, there being three species in New Zealand, including the common *N. clavicornis* Fabr. (fig. Q3) found on the flowers of Compositae. The Australian species, *N. vinitor* Berg., commonly called the Rutherglen Bug, is abundant in Victoria and New South Wales, and does great damage to crops and fruit trees of all kinds.

Oxycarenus luctuosus Mont. et Sign. is a very small black and white bug which swarms in the interior of Australia, and is the only Australian representative of the subfamily Oxycareninae. Another small subfamily, the Cyminae, contains only four Australian species, all rare insects.

The Aphaninae are quite well represented both in Australia and New Zealand. In the latter country the best known species is *Margareta dominica* F. B. W., a shiny, dark brown bug which lives on sword-grass (*Gahnia*) and much resembles the seed of that plant. In Australia the best known genera are *Dieuches* and *Daerlac*. *Daerlac tricolor* Sign. (pl 12, fig. 2) is an interesting insect, 8 mm. long, black touched with yellowish on the hemielytra; it rather closely resembles an ant both in form and movements.

Family 2. **Pyrrhocoridae** (Red Bugs, Fruit Bugs) [Aus. 12, N.Z. 0]. These insects only differ from the Lygaeidae in the absence of ocelli and the more abundant venation of the membrane. The Australian species belong to the genera *Dindymus*, *Physopelta* and *Dysdercus*. *Dindymus versicolor* H. Sch. is the commonest species, a rather handsome red and black bug found in Tasmania and Eastern Australia, and recorded as having been introduced into New Zealand; it often damages fruit. *Ph. guttata* Bd. (pl. 12, fig. 3) is a fine red species with black membrane and a large black spot on each corium.

Family 3. **Coreidae** [Aus. 52, N.Z. 0]. In this family the antennae are 4-segmented and usually inserted on a level with the eyes; two ocelli are present, and the membrane of the hemielytron has numerous, closely placed, parallel veins. The Americans call these insects Squash Bugs, but this name is inappropriate to our species. Froggatt has called them Gum-tree Bugs, but this seems scarcely distinctive enough.

The archaic subfamily Amorbinae is purely Australian, and contains about twenty fine species placed in four genera. Of these the principal one is *Amorbus*, with numerous species which feed on eucalypts. The members of this genus are stoutly built, with swollen hind femora, but without projecting lateral angles on the pronotum; they have a very strong odour. *A. robustus* Mayr. (pl. 12, fig. 4) is a common species, dark brown in colour.

The Mictinae, a larger tropical group, are represented in Australia by a few species of *Mictis*, of which the Crusader Bug, *M. profana* Fabr. (pl. 12, fig. 5) is the commonest; it is a rather handsome bug, nearly an inch long, with projecting lateral angles on the pronotum; it is dark brown with a pale yellowish St. Andrew's cross on the hemielytra.

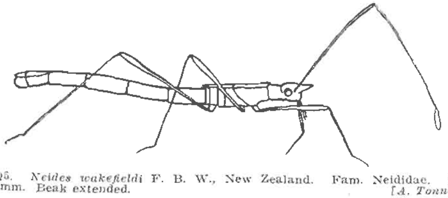


FIG. Q5. *Neides wakefieldi* F. B. W., New Zealand. Fam. Neididae. Length 6 mm. Beak extended. [*A. Tonnoir del.*

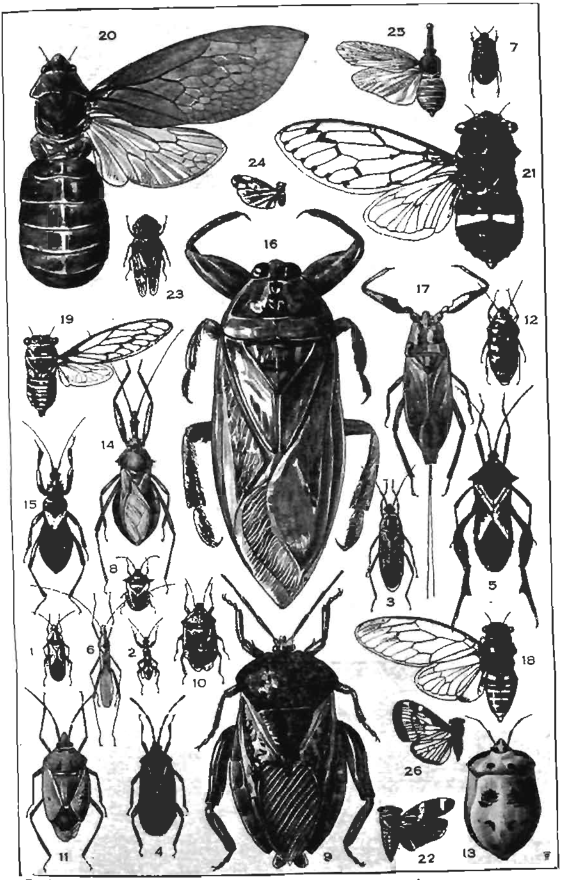
The Anisoscelinae are poorly represented by two species of *Leptoglossus* found in tropical Australia. *L. membranaceus* Fabr., is a handsome black bug with a transverse red stripe on the pronotum and a leaf-like dilatation on the hind tibiae; it ranges as far as Africa.

PLATE 12

HEMIPTERA

All figures natural size

1. *Lygaeus singularis* Walk. (Fam. LYGAEIDAE).
2. *Daerlac tricolor* Sign. (Fam. LYGAEIDAE).
3. *Physopelta guttata* Bd. (Fam. PYRRHOCORIDAE).
4. *Amorbus robustus* Mayr. (Fam. COREIDAE).
5. *Mictis profana* Fabr. (Fam. COREIDAE).
6. *Leptocorisa acuta* Thunb. (Fam. COREIDAE).
7. *Hahnia australis* Er. (Fam. CYDNIDAE), Aus. and N.Z.
8. *Dinadicus pallidus* Dall. (Fam. PENTATOMIDAE).
9. *Oncomeris flavicornis* Burm. (Fam. PENTATOMIDAE).
10. *Cermatulus nasalis* Wwd. (Fam. PENTATOMIDAE).
11. *Poecilometis gravis* Wwd. (Fam. PENTATOMIDAE).
12. *Scutiphora pedicellata* Kby. (Fam. PENTATOMIDAE).
13. *Tectocoris lineola* Fabr. (Fam. PENTATOMIDAE).
14. *Pristhesancus papuensis* Stal. (Fam. REDUVIIDAE).
15. *Pirates ephippiger* Wh. (Fam. REDUVIIDAE).
16. *Lethocerus indicus* Stal. (Fam. BELOSTOMATIDAE).
17. *Laccotrephes tristis* Stal. (Fam. NEPIDAE).
18. *Pauropsalta mneme* Walk. (Fam. CICADIDAE).
19. *Burbanga gilmori* Dist. (Fam. CICADIDAE).
20. *Cystosoma saundersi* Wwd. (Fam. CICADIDAE).
21. *Henicopsaltria fullo* Walk. (Fam. CICADIDAE).
22. *Eurymeloides pulchra* Sign. (Fam. JASSIDAE).
23. *Stenocotis caudata* Walk. (Fam. JASSIDAE).
24. *Eocenchrea maorica* Kirk. (Fam. DERBIDAE), N.Z.
25. *Eurinopsyche doddi* Dist. (Fam. FULGORIDAE).
26. *Scolypopa australis* Walk. (Fam. RICANIIDAE).



P. Tillyard del.

HEMIPTERA

The Alydinae include several Australian species of the tropical genus *Riptortus*, moderately slender bugs of fairly large size, with two spines on prothorax and both abdomen and wings slightly pinched in at the waist. *R. annulicornis* Guer., a dark reddish-brown species 16 mm long, is found in Queensland.

The Leptocorisinae are very slender species with narrow hemielytra. Several species of the tropical genus *Leptocorisa* occur in Australia. *L. acuta* Thunb. (pl. 12, fig. 6), reddish brown in colour, is common in Eastern Australia.

Family 4. **Neididae (Berytidae)** (Stilt Bugs). [Aus. 1, N.Z. 1]. This family is easily recognized by its slender body, long legs and elbowed antennae; in other respects it comes close to Coreidae. *Neides wakefieldi* F. B. W. (fig. Q5) the only known New Zealand species, is brachypterous; it is sometimes beaten from creepers in the bush. *Capyella lobulata* Berg. is the only recorded Australian species.

Family 5. **Cydnidae** (Burrower Bugs), [Aus. 28, N.Z. 3]. These are rather small to medium-sized, blackish bugs which live on the ground, under logs and stones, and run very rapidly; they might at first sight be mistaken for beetles. They agree with the Pentatomidae in the enlarged scutellum, but differ from them in form and habits, and particularly in their ability to burrow and in having thickly spinose hind tibiae. *Hahnia australis* Er. (pl. 12, fig. 7) and *Chaerocydnus nigrosignatus* F. B. W. occur in both countries. Most of the Australian species belong to the widespread genera *Geotomus* and *Adrisa*.

Family 6. **Pentatomidae** (Stink-bugs, Shield-bugs) [Aus. 374, N.Z. 10]. This is the dominant family of the Suborder, containing many large and handsome species, almost all of which are noted for their detestable odour. They are at once recognized by the large size of the scutellum, which always extends backwards beyond the end of the clavus, and may even cover the whole of the abdomen, as in the Scutellerinae. The antennae have five segments, or, more rarely, only four; two ocelli are present. Most of the species suck the juices of plants, a number being injurious to fruit trees and vegetables. A few are carnivorous and beneficial, attacking other insects and sucking their blood. The Australian species are chiefly found in the warmer parts of the continent; New Zealand is unaccountably poor in these insects.

The Acanthosomatinae are a primitive group of rather small, dull-coloured species, well represented in Australia by more than 30 species, mostly belonging to endemic genera, the best known being *Amphaces*, *Andriscus*, *Duadicus*, *Stauralia* and *Stictocarenus*. Three species of *Duadicus* occur in Australia, including the brownish *D. pallidus* Dall. (pl. 12, fig. 8). *Rhopalimorpha* has one species *Rh. humeralis* Walk. in Australia, and two in New Zealand, *Rh. obscura* F. B. W. (fig. Q4) and *Rh. ignota* Hutt. (Chatham Is.). The allied subfamilies Urolabinae, Phyllocephalinae and Dinidorinae have only one or two Australian genera apiece; the best known species is the Dinidorine *Megymenum insulare* Wwd., 12 mm. long, dark brown and rugose, found in subtropical scrub in Eastern Australia. The Aphylinae, containing only the two species of *Aphylum*, are peculiar, rounded bugs confined to Australia.

The Tessaratominae contain several fine species, including the largest of all Australian Pentatomids, *Oncomeris flavicornis* Burm. (pl. 12, fig. 9), found in the North Queensland scrub; it is a broad and handsome species measuring up to 40 mm. in length, with black, rugose thorax, black legs and dark maroon abdomen; the hemielytra have the corium irregularly marked with black and orange, the membrane purplish or dark steel-colour. *Rhaecocoris sulciventris* Stal. and *Stilida indecora* Stal. are two dark brown species, 20-25 mm. in length, which damage orange orchards in Eastern Australia.

The Asopinae contain two highly beneficial species found both in Australia and New Zealand, viz. *Cermatulus nasalis* Wwd. (pl. 12, fig. 10) which attacks the Pear-slug (larva of *Caliroa limacina* de Geer) and *Oechalia consocialis* Bd. which preys upon noxious caterpillars, including that of the Vine Moth (*Phalaenoides glycine* Lew.).

The dominant subfamily Pentatominae contains the great majority of the Australian stink-bugs, but only four or five New Zealand species. *Glaucias amyoti* Wh. is an occasionally beneficial species found in both countries. All the species of *Dictyotus*, except only *D. caenosus* Wwd., found in Tasmania and New Zealand, are purely Australian. *Eumecopus* and *Poecilometis* are endemic Australian genera of wattle-feeders, dull brown or reddish brown in colour; the best known species are *E. australasiae* Don., *P. histricus* Stal., *P. strigatus* Wwd. and *P. gravis* Wwd. (pl. 12, fig. 11). *Commius elegans* Don. (pl. 6, fig. 12)

is a widespread Australian species of peculiar colouring. *Catacanthus nigripes* Stal. (pl. 11, fig. 7) is a large and very handsome bug found in N. Queensland. *Agonoscelis rutila* Fabr. (pl. 11, fig. 8) is a small but brightly coloured species, widespread in Eastern Australia. *Plautia* and *Cuspicona* contain a number of green species, some of which damage crops. *Biprorulus bibax* Bred. (pl. 6, fig. 11) is a handsome green species, with sharp spines on the pronotum; it damages orange orchards. *Nezara viridula* L. (fig. A20), a handsome green species introduced not many years ago, is now a serious pest doing great damage to beans, berries and tomatoes around Sydney; it has also been recorded from New Zealand.

The Graphosomatinae connect the more typical forms with the Scutellerinae and Plataspinae, and have the scutellum greatly enlarged. The small brown bugs of the genus *Tectrica* feed on eucalypts and are peculiar to Australia; *T. lubala* Stal. is the best known species.

The Scutellerinae are a highly specialized group of handsome bugs having the scutellum very convex and enlarged so as to cover the whole of the abdomen, entirely concealing the wings; most of the species are tropical. *Scutiphora pedicellata* Kby. (pl. 12, fig. 12) and *Choerocoris paganus* Fabr. are two brilliantly coloured species found commonly around Sydney. *Tectocoris lineola* Fabr. (pl. 12, fig. 13) ranges from Eastern Australia to China; it is bright orange, with very variable markings suggestive of Chinese characters. The genus *Calliphara* contains six very fine species found in Queensland; *C. imperialis* Fabr. is a brilliant red bug measuring nearly an inch in length. *Cantao parentum* F.B.W. (pl. 11, fig. 9) is a handsome bug of an elongated shield-shape, deep red with black spots, found in Queensland.

The Plataspinae are a small group of very broad, short species allied to the Scutellerinae, with the immense scutellum entirely concealing the wings. Six species of the widespread tropical genus *Coptosoma* occur in Australia.

Superfamily II. ARADOIDEA.

Family 7. **Aradidae** (Flat Bugs, Fungus Bugs) [Aus. 17, N.Z. 3]. These are dull coloured bugs, very much flattened in shape, with short, bent beak and usually with short, five-segmented antennae; the hemielytra do not completely cover the abdomen. They live on fungi and hide under bark or

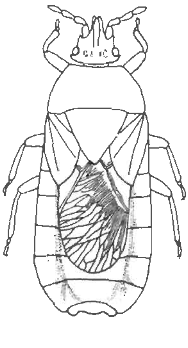


FIG. Q6. *Ctenoneurus hochstetteri* Mayr, New Zealand. Fam. Aradidae. Length 8 mm. [*A. Tonnoir del*

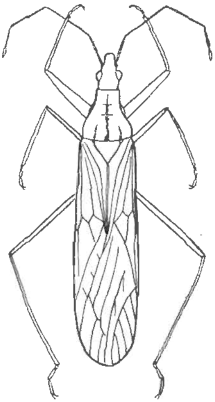


FIG. Q7. *Nabis capsiformis* Germ., New Zealand. Fam. Nabidae. Length 8 mm. [*A. Tonnoir del.*

dead wood. The subfamily Aradinae is represented in Australia chiefly by species of *Brachyrhynchus* and *Neuroctenus*. *Aradus australis* Er. is recorded from both countries, and is often found in houses. An excellent account of the life history of the common New Zealand species *Ctenoneurus hochstetteri* Mayr., (fig. Q6) has been given by J. G. Myers. The Isoderminae are an aberrant group confined to Australia, Tasmania and Southern Chile. *Isodermus planus* Er. and *I. vacillans* Walk. occur in Tasmania, *Procympiutus nasutus* Berg. in Australia.

Superfamily III. REDUVIOIDEA

This group consists entirely of bugs predatory on other insects; they have narrow, mobile heads with the ocelli placed behind the eyes, the beak usually short and very curved (long in Nabidae) and held well away from the underside of the head. In build they are mostly long and rather narrow, though some of the more robust forms have a fairly wide abdomen, which may exceed the width of the folded hemielytra. The three families are easily separated as follows:—

1. Tarsi 1-segmented in fore legs, 2-segmented in middle and hind legs; head globular, swollen behind the eyes; hemielytra entirely membranous and used in flight. Fam. 10. HENICOCEPHALIDAE
   Tarsi 3-segmented; head narrow; hemielytra not used in flight, and, except in Emesinae, provided with distinct corium and membrane. 2
2. Beak 3-segmented, short; prosternum with a stridulatory groove. Fam. 9. REDUVIIDAE
   Beak 4-segmented, long; prosternum without a stridulatory groove. Fam. 8. NABIDAE

Family 8. **Nabidae** [Aus. 1, N.Z. 2]. A small family related to the Reduviidae, but differing in the long, 4-segmented beak, in the absence of a stridulatory groove in the prosternum, and in the less specialized venation. The only recorded genus is *Nabis* (*Reduviolus*); the best known species is the New Zealand *N. capsiformis* Germ. (fig. Q7). *N. maoricus* Walk. is also found in New Zealand, *N. geniculatus* Er. in Tasmania.

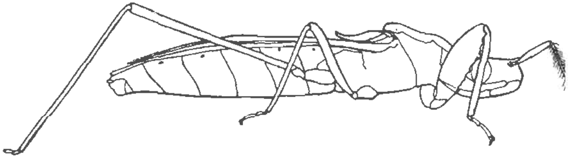


FIG. Q8. *Oncocephalus confusus* Reut., Australia. Fam. Reduviidae, subfam. Stenopodinae. Length 17 mm. [*E. S. Gourlay del.*

Family 9. **Reduviidae** (Assassin-Bugs) [Aus. 124, N.Z. 4]. These beneficial insects prey on other insects, sucking their blood; they can be at once distinguished by the curved beak, which stands well away from the head basally, by the very narrow head, always longer than broad, and by the presence of two or three large rounded cells at the base of the membrane of the hemielytron.

Of the numerous subfamilies, the most abundant and most typical of the family are the Harpactorinae, well represented in Australia by about 40 species, mostly belonging to endemic genera. The four species of *Havinthus* are beautiful black and red insects, one of the handsomest being *H. rufovarius* Berg. (pl. 11, fig. 10). *Gminatus* includes a number of longer and duller coloured species having the abdomen nipped in at the waist and broadly rounded behind; *G. australis* Er. is not uncommon hunting over tree-trunks and perhaps attacking ants. Two tropical genera with species of large size are *Helenotus* and *Pristhesancus*, both occurring also in Papua; *P. papuensis* Stal. (pl. 12, fig. 14), is the largest species ranging from Papua to Northern New South Wales; it is concave above, the lateral edges of the abdomen being raised up above the level of the hemielytra. This species is known as the Bee-killer; it sits about on flowers and seizes honey-bees and other insects.

The Piratinae are represented in Australia by more than 20 species, more than half of which belong to the fine genus Pirates. P. ephippiger Wh. (pl. 12, fig. 15), the best known species, is 18-20 mm. long, dull blackish, with a patch of yellow covering the bases of the clavi.

The Reduviinae (or Acanthaspinae) are represented only by a few species belonging to endemic Australian genera and by the widespread *Reduvius personatus* L., which ranges as far as Europe.

In the Holoptilinae the best known forms are the species of *Ptilocnemus*, an endemic Australian genus remarkable for the thick tufts of hair on the hind legs. *Pt. femoratus* Horv. (pl. 6, fig. 13) is a very beautiful black and yellow species. The genera *Orthocnemus* and *Aradellus* are also peculiar to Australia.

The Stenopodinae are represented by few genera, the principal one being *Oncocephalus* with five species. *O. confusus* Reut. (fig. Q8) is a fine species 17 mm. long, of fairly slender build, dull brownish with small black patches on corium and membrane.

Opistoplatys australasiae Wwd. and *O. fuscus* Stal. are two very flat Reduviids placed in the small subfamily Tribocephalinae; the former is 14 mm. long, dark brown with black hemielytra and antennae with soft hairs.

The highly specialized Emesinae or Ploeariinae occur not uncommonly both in Australia and New Zealand, though few of the species have so far been described. The genus *Ploearia* is represented by *P. geniculata* Stal. in Australia, and by *P. huttoni* Scott in New Zealand; this latter wingless species also occurs, remarkably enough, on the island of Juan Fernandez. Bergroth holds this to be one of the proofs of an original land connection between New Zealand and Chile. *Ploeariodes rubromaculatus* Blkb. occurs in Australia, New Zealand, Fiji, Hawaii, California, Juan Fernandez and Madeira! Other Australian genera are *Gardena, Stenolaemus, Leistarches* and *Bargylia*.

Family 10. **Henicocephalidae** [Aus. 2, N.Z. 2]. These very small bugs differ from the previous family in having the hemielytra entirely membranous and used for flight, the head globular and swollen behind the eyes. *Henicocephalus maclachani* Kirk. and an undescribed species occur in New Zealand. *H. tasmanicus* Wwd. and *Systelloderes aetherius* Berg. in Tasmania. These insects fly in the evening in swarms, dancing in the air like gnats.

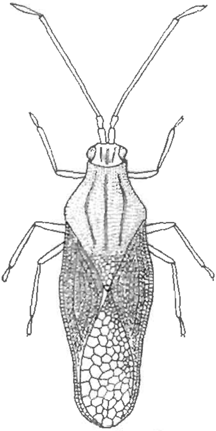


FIG. Q9. *Froggattia olivina* Horv., Australia. Fam. Tingidae. Length 3 mm.

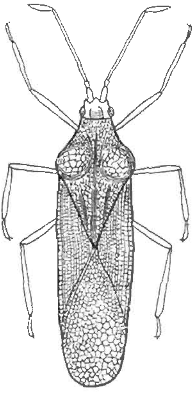


FIG. Q10. *Oncophysa vesiculata* Stal., Australia. Fam. Tingidae. Length 3 mm. [*A. Tonnoir del.*

Superfamily IV. TINGOIDEA

A small group containing only minute insects of very beautiful sculpturing, with elongate, 4-segmented antennae, the distal segment more or less clubbed; tarsi 2-segmented. Their affinities are somewhat problematical. Two families are known, of which the *Piesmatidae** have not yet been recorded either from Australia or New Zealand; they can be distinguished by the following Key:—

Pronotum entirely concealing scutellum. Fam. 11. TINGIDAE
Pronotum normal, not concealing scutellum. (Fam. PIESMATIDAE)*

Family 11. **Tingidae** (*Lace Bugs*) [*Aus. 8, N.Z. 1*]. These very small, handsome bugs are plant-feeders, sometimes damaging plants and fruit-trees; they are easily recognized by the beautiful and intricate, raised lacework pattern occurring all over both corium and membrane of the hemielytron. *Froggattia olivina* Horv. (fig. Q9) damages olive trees in Australia. *Oncophysa vesiculata* Stal. (fig. Q10), found round Sydney, has two large bladder-like swellings on the pronotum. The family was unknown in New Zealand until recently, when J. G. Myers discovered a tiny new species while sweeping sedges and rushes.

Superfamily V. MIROIDEA.

A group of small species of very varied feeding habits, but mostly vegetarian. The character of having the meso- and metapleura formed of more than one piece is absolutely diagnostic for this group, but not always easy to apply to very small, obscurely marked species in practice. Most of the forms are, however, winged, and the examination of the hemielytron is an easy matter; the

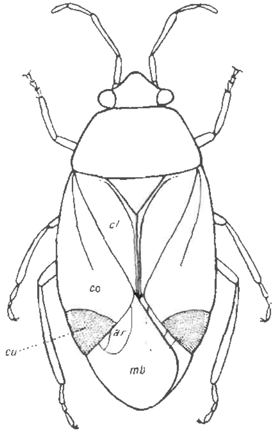


FIG. Q11. *Romna* sp. indet., New Zealand. Fam. Miridae. *ar*, areolus; *cl*, clavus; *co*, corium; *cu*, cuneus; *mb*, membrane. Length 9 mm. [*A. Tonnoir del.*

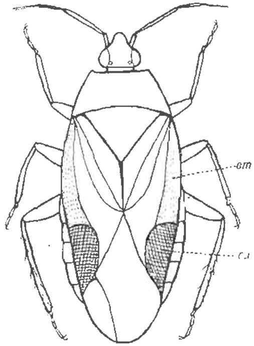


FIG. Q12. *Lyctocoris campestris* Fabr., Australia and New Zealand. Fam. Anthocoridae. Length 3.5 mm.; *cu*, cuneus; *em*, embolium. [*A. Tonnoir del.*

presence of a *cuneus* (figs. Q11, 12, *cu*) distinguishes any member of the group at once. The three families may be separated as follows:—

1. Wingless or brachypterous, blood-sucking species. Fam. 14. CIMICIDAE
   Species not blood-sucking, usually fully winged. 2

*Greek *piesma* a pinching or squeezing, gen. *piesmatos*, stem *piesmat-*.

2. Hemielytron without an embolium. Fam. 12. MIRIDAE
Hemielytron with an embolium. Fam. 13. ANTHOCORIDAE

Family 12. **Miridae (Capsidae)** (Plant Bugs, Leaf Bugs) [Aus. 55 N.Z. 10]. One of the most universally abundant families of the Heteroptera, but little worked in either country owing to the small size and unattractive appearance of most of the species. Most of them feed on plants and some are highly injurious to crops. The Australian species belong to the genera *Miris*, *Austromiris*, *Lopus*, *Eurybrochis*, *Eucerocoris*, *Kirkaldyella*, *Myrmecoridea*, *Zanessa*, *Cyrtorhinus* and others. *Z. rubrovariegata* Kirk. is about 8 mm. long, brown with red on the hemielytra. *C. mundulus* Bred. is a beneficial species found in Queensland, where it feeds on the eggs of injurious leaf-hoppers such as *Perkinsiella*, a pest of sugar-cane (p. 167); it has been introduced into Hawaii by F. Muir, and has proved highly beneficial there. New Zealand has many species, few of which have yet been described; of these, the finest are the species of *Romna*, *R. scotti* F.B.W., *R. capsoides* F.B.W. and a large, undescribed species (fig. Q11). The introduced *Stenotus binotatus* Fabr. swarms on introduced grasses in New Zealand, and often does considerable damage.

Family 13. **Anthocoridae** (Flower Bugs) [Aus. 6, N.Z. 4]. Small species distinguished by having two ocelli and hemielytron with both cuneus and embolium. They are probably numerous in both countries, but very few have been described. The most interesting genus is *Cardiastethus*, found amongst fungi in New Zealand. The Australian genera are *Hoplobates*, *Buchananiella* and *Lasiellidea*. The world-wide *Lyctocoris campestris* Fabr. (fig. Q12) is found in both countries.

Family 14. **Cimicidae** (Bed Bugs). Dorso-ventrally flattened, blood-sucking parasites of mammals and birds: ocelli absent, tarsi 3-segmented, hemielytra absent or very short. Only represented in both countries by the detestable and all too common introduced Bed Bug, *Cimex lectularius* L., which is too well known to need description here.

Superfamily VI. GERROIDEA

This group contains aquatic or semi-aquatic forms, easily recognized by the velvety, silvery pubescence on the underside of the body. The Water-striders (families Hydrometridae and Gerridae) appear to be a specialized offshoot from the Reduvioidea; the affinities of the obscure Hebridae are more doubtful. The families are separated as follows:—

1. Minute, semi-aquatic forms with 5-segmented antennae. Fam. 15. HEBRIDAE
Forms mostly of larger size, with 4-segmented antennae. 2
2. Body long and very slender Fam. 16 HYDROMETRIDAE
Body comparatively short and stout. Fam. 17. GERRIDAE

Family 15. **Hebridae** [Aus 1, N.Z. 0]. An obscure family of minute, semi-aquatic species with 5-segmented antennae and hemielytra mostly membranous. The only recorded species is *Hebrus axillaris* Horv. from New South Wales.

Family 16. **Hydrometridae** (Slender Water-striders) [Aus. 3, N.Z. 0]. All the Australian species belong to the genus *Hydrometra*, the best known being *Hydrometra strigosa* Sk. (fig. Q13), found in swamps near Sydney; it is dark brownish in colour, with a slight pattern, and is about half-an-inch long.

Family 17. **Gerridae** (Water-striders) [Aus. 7, N.Z. 2]. These active, rather stout and short-bodied insects, with strong, often rather long, legs, are to be seen striding or skating rapidly on the surface of water and attacking other insects. The subfamily Gerrinae is represented by three species of *Gerris* in Australia; *G. australis* Sk. is about 8 mm. long, dark olive above, greyish yellow beneath; it was found on Sydney Harbour. The smaller insects of the subfamily Veliinae occur in both countries, the genus *Microvelia* being represented by *M. australica* Berg. in Australia and *M. macgregori* Kirk. and an undescribed species (fig. Q14) in New Zealand. The peculiar marine bugs of the subfamily Halobatinae are represented by *Halobates whiteleggi* Sk. from Sydney Harbour and *Hermatobates haddoni* Carp. from Torres Straits; they have a strongly convex, oval body, composed chiefly of the large, fused meso- and metathorax, and are destitute of wings; they are said to feed on small marine animals just after death, but it would seem very probable that they can catch and kill their prey if necessary.

Superfamily VII. SALDOIDEA

These peculiar bugs stand far apart from all other Gymnocerata, and form a connecting link with the Ochteridae, which are placed in the Cryptocerata. They

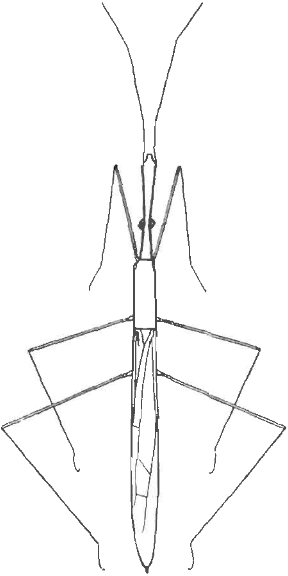


FIG. Q13. *Hydrometra strigosa* Sk., Australia. Fam. Hydrometridae. Length 11 mm. [*A. Tonnoir del.*

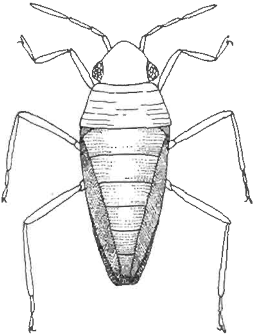


FIG. Q14. *Microvelia* sp. indet. Kirk., New Zealand. Fam. Gerridae. Length 2 mm. [*A. Tonnoir del.*

are very active, soft-bodied insects, with wide head, large, prominent eyes placed wide apart with the ocelli between them, beak long but not appressed to underside of body, tarsi 3-segmented, hemielytra divided into corium, membrane and clavus.

Family 18. **Saldidae (Acanthiidae)** (Shore Bugs) [Aus. 3. N.Z. 3]. Species of *Salda* (fig. Q15) occur in both countries, but few have been described; they keep close to fresh water, and may be found running about over rocks and stones on the margins of lakes and rivers. One species of *Chiloxanthus* is found in Australia.

Division *CRYPTOCERATA*

The members of this Division are almost all aquatic or semi-aquatic species, and may be recognized by the antennae being shorter than the head, and, except in the case of the Ochteridae, entirely concealed beneath it; meso- and metasternum are formed of several pieces, stink glands are never present, and the hemielytron always has a large corium with a comparatively narrow distal mem-

brane. There are eight families, all of which occur in Australia but only three in New Zealand; they are grouped into four superfamilies as follows:—

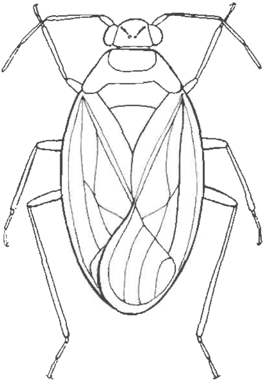


FIG. Q15. *Salda* sp. indet., New Zealand. Fam. Saldidae. Length 5 mm. [*A. Tonnoir del.*

1. Terrestrial species inhabiting the forest floor, and having the hemielytra and lateral expansions of the thorax with a network of veins. VIII. PELORIDIOIDEA
   Riparian or aquatic forms, without the above network of veins. 2
2. Ocelli present; riparian forms. IX. OCHTEROIDEA
   Ocelli absent; aquatic forms. 3
3. Head normally inserted into prothorax, not overlapping or covering it. X. NOTONECTOIDEA
   Head overlapping prothorax dorsally, entirely hiding it. XI. CORIXOIDEA

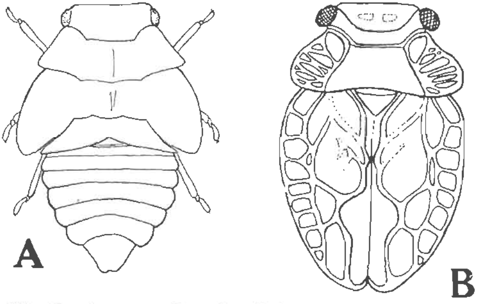


FIG. Q16. *Xenophyes cascus* Berg., New Zealand. Fam. Peloridiidae. A, last larval instar. Length 2 mm. (*Original drawing by A. Tonnoir*). B, Imago. Length 3 mm. (*After Bergroth*).

Superfamily VIII. PELORIDIOIDEA.

This group includes only a single very small family.

Family 19. **Peloridiidae** [Aus. 1, N.Z. 1]. A very small family which includes only three species, viz., *Peloridium hammoniorum* Bred. from the Straits of Magellan, *Hemidoecus leai* China from Tasmania, and *Xenophyes cascus* Berg. (fig. Q16) from New Zealand. These little insects inhabit the forest floor, living in leaf-mould. They agree with the Ochteridae in the structure of their antennae, legs and number of tarsal segments, but differ in carrying the antennae concealed and in the presence of a network of veins on the hemielytra and lateral expansions of the thorax. The most extraordinary character is the Homopteroid form of the head and beak.

Superfamily IX. OCHTEROIDEA

A small group containing only two families, neither of which has so far been found in New Zealand. The following Key separates the families:—

Antennae not concealed; forelegs not raptorial. Fam. 20. OCHTERIDAE
Antennae concealed; forelegs raptorial. Fam. 21. GELASTOCORIDAE

Family 20. **Ochteridae** [Aus. 1, N.Z. 0]. The only species is *Ochterus marginatus* Latr., which is fairly common throughout Australia and ranges to India, China, South Africa and Central Europe; it lives on damp banks and in swamps, and is usually found on sandy patches in such places.

Family 21. **Gelastocoridae (Galgulidae)** (Sand-bugs) [Aus. 9, N.Z. 0]. The Australian species all belong to *Mononyx* and *Matinus*, in both of which the larvae have the tarsi 2-segmented but the adults have them unsegmented. The best known species in *Mononyx annulipes* Horv., a very broad bug, rounded behind but truncated in front, about 6 mm. long, of a dull brown colour, with rugose hemielytra.

Superfamily X. NOTONECTOIDEA

This well marked group contains only aquatic species, the four families being separated as follows:—

1. End of abdomen with an elongated respiratory siphon. Fam. 22. NEPIDAE
   End of abdomen without a siphon. 2

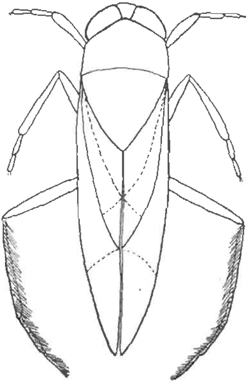


FIG. Q17. *Anisops assimilis* F.B.W., New Zealand. Fam. Notonectidae. Length 8 mm. [*A. Tonnoir del.*

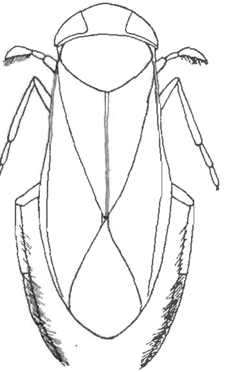


FIG. Q18. *Arctocoriso arguta* F.B.W., New Zealand. Fam Corixidae. Length 6.5 mm. [*A. Tonnoir del.*

2. Body flattish or only slightly convex above, the insect swimming in normal fashion; forelegs inserted at or near anterior margin of prosternum. 3
Body exceedingly convex above, the insect swimming on its back; forelegs inserted on the hind margin of the short prosternum.
Fam. 25. NOTONECTIDAE

3. Beak without labial palpi; hind tibiae with small spines.
Fam. 23. NAUCORIDAE
Beak with labial palpi; hind tibiae with swimming hairs.
Fam. 24. BELOSTOMATIDAE

Family 22. **Nepidae** (Water-Scorpions) [Aus. 5, N.Z. 0]. The members of this family live in mud or weeds at the bottom of ponds and waterholes, and are popularly known as "Toe-biters" or "Needle-bugs" in Australia, owing to their habit of attacking bathers and inflicting painful stabs. They are easily recognized by the small, globular coxae and by the presence of two elongated processes forming a respiratory siphon at the end of the abdomen; the forelegs are raptorial, and are inserted on the front margin of the prosternum. The hemielytra and wings are well formed, folded closely against the body; when, as often happens, the water in which the insect lives dries up, it is capable of flying considerable distances to fresh supplies. The genera *Laccotrephes* and *Ranatra* are each represented by two widespread species. *L. tristis* Stal. (pl. 12, fig. 17) is a weed-dwelling species of a dull brown colour, with the abdomen coloured red under the hemielytra. *Ranatra australiensis* Hale, the common Australian Needle-bug, is a slender, dark brown, mud-dwelling insect with a body up to 2 inches in length and respiratory siphon almost as long.

Family 23. **Naucoridae** [Aus. 3, N.Z. 0]. All the Australian species belong to *Naucoris*, the best known being *N. australicus* Stal. They resemble smallish Belostomatidae, being of the same oval shape and brownish colour, and averaging about half-an-inch in length; the absence of the labial palpi and of the swimming-hairs of the hind tibiae will serve to distinguish them. The family appears to be an ancient one, probably directly descended from the Triassocoridae of the Upper Triassic of Ipswich, Q.

Family 24. **Belostomatidae*** [Aus 4, N.Z. 0]. These water-bugs are active swimmers with strong raptorial forelegs, fringes of swimming hairs on hind tibiae and tarsi, and small labial palpi present at base of beak. The Giant Fish-killer, *Lethocerus indicus* Stal. (pl. 12, fig. 16), is a huge insect ranging from India to Australia; it often leaves the water and flies great distances, and is sometimes attracted in numbers to electric lights in Sydney and Brisbane. The much smaller and more broadly oval species of the genus *Sphaeroderma* superficially resembles Naucoridae; they live in water-weeds, and the female lays her eggs in a mass on the back of the male, who carries them about with him until they hatch. *S. rusticum* Fabr. is common throughout Australia and ranges to India and the Philippines.

Family 25. **Notonectidae** (Back-swimmers) [Aus. 11, N.Z. 2]. In this family the tarsi are normally 2-segmented; sometimes the fore tarsi, or fore and middle, have only a single segment. The underside of the abdomen carries a median, longitudinal keel with a trough on each side, over which a series of specialized hairs closes so as to imprison the air which is required for breathing during submergence. The insects rest with the long hind-legs projecting obliquely forwards in a characteristic position. The eggs are inserted into the tissues of water-weeds.

The species are all carnivorous, being especially partial to a diet of Mosquito or other Dipterous larvae. Both the New Zealand species, and all but three of the Australian, belong to the dominant genus *Anisops*. *A. assimilis* F. B. W. (fig. Q17) is common in New Zealand; *A. hyperion* Kirk., *A. doris* Kirk. and *A. stali* Kirk. are all widely distributed in Australia. The other genera found in Australia are *Notonecta*, *Enithares* and *Plea*.

Superfamily XI. CORIXOIDEA

The single family Corixidae, which comprises this group, stands far apart from all other Cryptocerata in the peculiar characters of the head, beak and forelegs. The head completely overlaps the prothorax above, so that the latter is not visible; below, it curves backwards to between the fore coxae, and ends in a

*Greek *belos*, a dart, and *stoma*, a mouth, gen. *stomatos*, stem *stomat-*.

very short, flattened beak. The fore tarsus consists usually of a single segment, termed the *pala*, forming a more or less falcate scoop, furnished with a row of stiff bristles; in the males, a series of small pegs or tooth-like processes also occur, and are supposed to be the organs which produce the characteristic stridulations beneath the water, by rubbing against a finely toothed area on the femur. The pala usually has no claw, but in some genera it ends in a single claw or a bristle. The Australian species have been proved by Hale to be carnivorous, feeding on mosquito and other insect larvae; but Hungerford in America has reared Corixidae on algae and the sediment of ponds. Probably they are almost omnivorous.

Family 26. **Corixidae** (Water-boatmen) [Aus. 14, N.Z. 3]. Four genera occur in Australia, viz., *Arctocorisa*, *Porocorixa*, *Micronecta* and *Diaprepocoris*; only the first and last of these are found in New Zealand. The commonest Australian species are *A. australis* Fieber, *P. eurynome* Kirk. and *P. parvipunctata* Hale; the seven species of *Micronecta* are not so frequently met with. In New Zealand *A. arguta* F.B.W. (fig. Q18) is the commonest species; it is a handsome, brown insect, mottled all over with tiny spots of darker brown. *All the species swim rapidly in still waters by means of their* oar-like hindlegs. The eggs are stalked and attached to the stems of water-weeds.

Suborder HOMOPTERA

(Cicadas Plant-hoppers, Plant-lice, Scale Insects).

This Suborder has the head highly specialized, as indicated in the Key on p. 144, but the wings are much more primitive than those of the Heteroptera. The forewing shows no sharp division into corium and membrane, and is termed a *tegmen*, being usually of the same consistency throughout, and only seldom even with a faint line dividing it transversely; venation generally complete. Wings usually held roof-wise over the body, only seldom folded flatly, and then not completely overlapping distally (except in a few Achilidae). The straight beak is in line with the mid-ventral surface of the greatly inflexed head (fig. Q1) and extends backwards between the forelegs, the sides of the head being in contact with the fore coxae. An extraordinary internal structure of great interest, found in all Homoptera except the Jassidae and Fulgoroidea, is the wonderful *filter* by means of which the liquid food is "short-circuited" from the crop to the hind-gut, only the more solid matter passing through the mid-gut. All the species suck the juices of plants. Australia has about 1100 species, including 330 Coccidae and 180 Cicadas; New Zealand has only 230 species, over 100 being Coccidae.

In the classification of this Suborder, the chief points to bear in mind are the form of the antennae, the structure of the tarsi, (i.e., the number of segments, the number of claws and the presence or absence of an empodium between them), the number and position of the ocelli, the form of the head-sclerites, the condition of the coxae, and certain details of venation. For the head, the student must be able clearly to distinguish the limits of the epicranium, frons, clypeus and genae (fig. Q1), and must bear in mind that, owing to the inflexion of the head, these parts are often placed much further ventrad than in most insects. The *forewing*, or *tegmen*, has a very variable type of venation, generally characterized by more or less fusion of the basal portions of two or more of the main veins; when these are all fused together from Sc to Cu_1, as in the most highly reduced types, then the fused stem is spoken of as the *principal vein*. In many forms Sc is entirely absent, and often R_1 is absent also, or only appears as a small end-twig of R_{2+3}*; M is normally three or four-branched, and Cu_1 has a terminal fork in most cases. Cu_2 is a deeply impressed furrow-vein, forming the *vena dividens*, separating off the very distinct anal area or *clavus* from the rest of the wing in all except the most reduced forms. The *clavus* itself is generally more or less triangular or elongated in form, with a sharp distal angle or *apex*; it usually carries only two anal veins, *1A* and *2A*, though *3A* is present in some Fulgoroidea. Some of the Fulgoroidea have a highly specialized venation with abundant branchings, paralleling that of the Planipennia; in such forms, there is often a separate costal vein C, with a distinct *precostal area* between it and the costal margin. The hindwing is entirely membranous and usually has a folded anal area; its venation is comparatively simple, the main stems of R, M and Cu_1 being often quite separate.

*See remarks on p. 142 (fossils).

The Suborder falls naturally into two very distinct Divisions, according to the following Key:—

Tarsi 3-segmented; the beak clearly arising from the posterior ventral part of the head. Division *AUCHENORRHYNCHA*

Tarsi 2 or 1-segmented; the beak appearing to rise from between the fore legs. Division *STERNORRHYNCHA*

Division *AUCHENORRHYNCHA*

This Division contains all the larger and less specialized forms, in which the venation is for the most part not reduced, and sometimes even becomes secondarily increased, as in the higher Fulgoroidea. The Division is more primitive than the Sternorrhyncha in all characters except only the antennae, which are reduced to the two basal segments with a terminal flagellum composed of few more or less indistinct segments. It contains two well-marked superfamilies, as follows:—

Middle coxae short and close together; hind coxae mobile. Pedicel of antennae without sensillae, the flagellum with sensory grooves. Tegulae absent. Tegmen with the two anal veins not forming a Y-vein. XII. CICADOIDEA

Middle coxae elongate, placed wide apart; hind coxae immobile. Pedicel of antennae with numerous sensillae; a single large sense-organ on the basal segment of the flagellum. Tegulae present. Tegmen generally with the two anal veins forming a Y-vein. XIII. FULGOROIDEA

Superfamily XII. CICADOIDEA

In addition to the characters in the Key, it should be noted that the ocelli, which are seldom absent, are placed either on the vertex, on the front margin of the head, or between the eyes. There are only four families, separated as follows:—

1. Hind coxae not reaching sides of sterna. 2
   Hind coxae transverse, reaching sides of sterna. 3
2. Ocelli three, on vertex; fore femora thickened; empodia absent; males usually with a sound-producing apparatus at base of abdomen. Fam. 27. Cicadidae
   Ocelli two or none; fore femora not thickened; empodia present, large; never any sound-producing apparatus. Fam. 28. Cercopidae
3. Pronotum hypertrophied, generally prolonged backwards over abdomen; genae not dilated. Fam. 30. Membracidae
   Pronotum never prolonged backwards over abdomen; genae dilated or broadened. Fam. 29. Jassidae

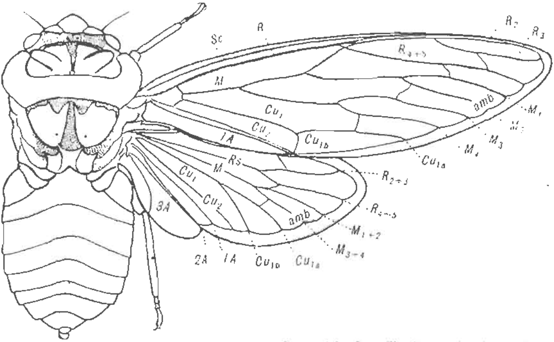


FIG. Q19. *Cyclochila australasiae* Don., Green Monday Cicada, male, Australia. Fam. Cicadidae, subfam. Cicadinae. Length of body 40 mm. Lettering as in fig. A8, p. 22, except *amb*, ambient vein. See remarks on p. 142 (fossils). [*A. Tonnoir del.*

Family 27. **Cicadidae** [Aus. 180, N.Z. 20]. The Cicadas, commonly but inaccurately called "locusts" both in Australia and New Zealand, are medium to large insects which are at once recognized by the shrill screech of the males during the summer months. The sound produced by the smaller

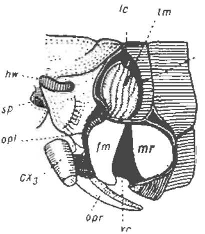


FIG. Q20. *Cyclochila australasiae* Don., male, left lateral and slightly ventral view of metathorax and first three abdominal segments, to show the sound-producing apparatus. *cx₃*, hind coxa; *fm*, folded membrane; *hw*, hindwing cut away; *lc*, lateral cavity; *mr*, mirror; *opl*, edge of left operculum cut away; *opr*, right operculum; *sp*, second thoracic spiracle; *tc*, edge of tympanal covering, cut away; *tm*, tympanum; *vc*, ventral cavity. Left operculum and tympanal covering removed to show the structures enclosed by them. [*R. J. T. del.*

species is pleasant enough to listen to, but that of the larger is ear-splitting and is frequently continued far into the night. The males alone produce the sound, the females being quite voiceless. The sound-producing structures are very complex and peculiar to the family. The most conspicuous parts, externally, are the two *opercula* (fig. *opl*, *opr*), which are large, latero-ventral, posterior expansions of the metasternum, covering the sound-organs more or less completely from below. On lifting one of the opercula, there will be seen a large cavity, called the *ventral cavity* (*vc*), whose dorsal or upper limits are chiefly formed by two tightly stretched membranes, viz., the anteriorly placed, whitish *folded membrane* (*fm*) and the posteriorly placed, tightly stretched, delicate, iridescent *mirror* (*mr*). Latero-dorsally from the folded membrane lies a smaller cavity, called the *lateral cavity* (*lc*), within which is a smaller, strongly ridged membrane called the *tympanum* or *timbal* (*tm*). In the highest subfamily, the Cicadinae, the latero-dorsal margins of the first abdominal segment are produced forwards so as to cover the tympanum from above; these expansions are called the *tympanal coverings* (*tc*); they are absent or imperfect in the other subfamilies. Three pairs of *spiracles* are covered by the *opercula*, viz., the second thoracic and those of the first two abdominal segments.

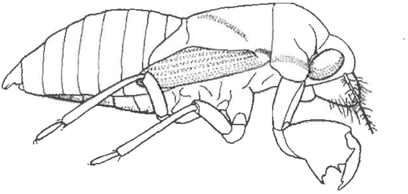


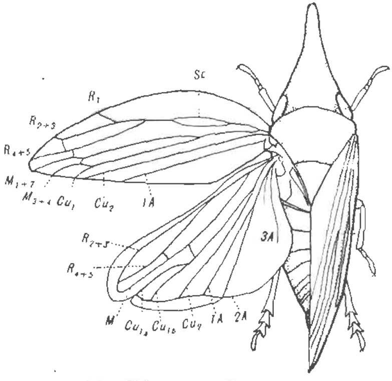
FIG. Q21. Burrowing larva of *Melampsalta cingulata* Fabr., last instar; New Zealand. Fam. Cicadidae, subfam. Tibicininae. Length 27 mm. [*A. Tonnoir del.*

Cicadas possess a strong beak (fig. Q1) with which they suck the sap of trees and shrubs. Some species do a considerable amount of damage, both in this manner and also by slitting the bark when laying their eggs. The larvae (fig. Q21) live underground, often taking two or three years or more to become full-fed; they have strong burrowing forelegs and feed by sucking the sap from the roots of trees and shrubs. The full-grown larva burrows upwards out of the ground

and climbs a tree-trunk or paling; then the adult cicada emerges, leaving behind the tough exuviae, which are common objects during the spring and summer months.

The most archaic subfamily is the Tettigarctinae, which includes only the two species of *Tettigarcta*, viz., *T. tomentosa* F.B.W. from Tasmania and *T. crinita* Dist. (pl. 11, fig. 11) from Victoria. They are very hairy, brown cicadas of about 3 inches expanse; the males are quite voiceless, without any vestiges of a sound-producing apparatus. The forewing has a strong transverse line suggestive of the beginnings of a division into corium and membrane.

The Tibicininae have the sound-producing organs of the male well developed, but without any tympanal coverings. All the New Zealand species belong here, being included in the genera *Melampsalta* and *Pauropsalta*, both of which are also well represented in Australia. *M. cingulata* Fabr. (pl. 2, fig. 9) is the largest New Zealand species, expanding about 3½ inches; it is of a pretty olive green colour with black markings, and has a loud chirp ending with a click of the wings. Common smaller species are the dark red *M. cruentata* Fabr. and the bright green *M. muta* Fabr.; *M. cincta* Walk. frequents sand dunes along the coast. There are about 50 Australian species of *Melampsalta* and 20 of *Pauropsalta*, mostly dark brown or blackish in colour, with yellow, orange or red markings. *M. torrida* Er. and *M. abdominalis* Dist. are common and widespread species. *Pauropsalia mneme* Walk. (pl. 12, fig. 18) is found on the Blue Mts., N.S.W., while the somewhat smaller *P. encaustica* Germ. is much commoner in most parts of Australia. This genus and the allied *Diemeniana*, from Tasmania, differ from *Melampsalta* in having one apical cell less in the hindwings. *Burbanga gilmori* Dist. (pl. 12, fig. 19) is a small greyish cicada from Queensland with narrow and rather prettily marked wings. The genus *Abricta* includes the largest Australian species of this subfamily. The "Floury Miller," *A. curvicosta* Germ., is 4 inches in expanse, reddish brown with whitish pubescence on abdomen; *A. aurata* Walk. is a somewhat smaller and darker species found in Tasmania and Victoria. The extraordinary Bladder Cicadas of the genera *Cystosoma* and *Chlorocysta* occur in the warmer parts of Eastern Australia; the finest species is *Cys-*



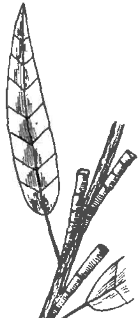


FIG Q22 (left). *Philagra parva* Dist., Australia. Fam. Cercopidae. Length 10 mm. Lettering as in fig. A8, p. 22. See remarks on p. 142 (fossils). [*A. Tonnoir del.*

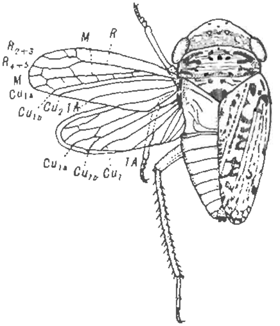
FIG. Q23 (right). Larval tubes of *Pectinariophyes* sp., Sydney, Australia, last instar, attached to twig of eucalyptus sapling. Length of tubes 10-12 mm. [*R. J. T. del.*

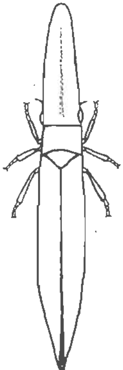
tosoma saundersi Wwd. (pl. 12, fig. 20), with inflated green abdomen and opaque green forewings with reticulate venation. The species of *Chlorocysta* are smaller, with hyaline wings and more normal venation.

The Cicadinae have complete tympanal coverings, and are represented in ew species occur in tropical Australia, belonging to the genera *Gaeana*, *Tettigia* und *Tamasa*.

The Cicadinae have complete tympanal coverings, and are represented in \ustralia by a number of endemic genera with large and handsome species. The enus *Macrotristria* contains a number of well-known species, including the comnon "Fiddler", *M. angularis* Germ., dark brown spotted with yellow, and having he veins of the distal part of the forewing heavily shaded. *Henicopsaltria* includes he handsome Mottled Brown Cicada, *H. eydouxi* Guer., a very common Eastrn Australian species expanding 5 inches, chestnut and pale brown in colour, vith reddish-orange opercula and lightly clouded venation on forewings, and the Vhite-banded Cicada, *H. fullo* Walk. (pl. 12, fig. 21), a handsome blackish pecies expanding only 3 inches, common in Western Australia. *Psaltoda moerens* ierm. is the common large Black Cicada, also called the Red Eye. *Ps. aurora*)ist. is a much handsomer allied species from N. Queensland. *Cyclochila ausralasiae* Don. is the very common large Green Monday Cicada (fig. Q19) exanding up to 5 inches; a rich yellow variety is called the Yellow Monday. The inest cicadas of all are the two handsome species of *Thopha*, a genus having he tympanal coverings hypertrophied and much larger than the opercula. The)ouble Drummer, *T. saccata* Fabr., is a handsome black and red species exanding 5 inches, ranging from South Australia to South Queensland; the allied *T. sessiliba* Dist. (pl. 11, fig. 12) is a rarer northern species of a lovely purplish rown colour.

Family 28. **Cercopidae** [Aus. 30, N.Z. 4]. This family contains the Frogoppers or Spittle-insects, the former name indicating their frog-like appearnce, the latter the habit of most of the larvae in secreting a mass of froth r "cuckoo-spit", within which they live, sucking the juices of plants. They are





'IG. Q24 (left). *Tylozygus cassiniae* Myers, New Zealand. Fam. Jassidae, subfam. Cicadellinae. Length 4 mm. Lettering as in fig. A8, p. 22. See remarks on p. 142 (fossils). [*R. J. T. del.*
'IG. Q25 (right). *Cephalelus hudsoni* Myers, New Zealand. Fam. Jassidae, subfam. Cephalelinae. Length 11 mm. [*A. Tonnoir del.*

losely allied to the Cicadidae, but have only two ocelli instead of three; the ibiae are smooth, and the hind pair are armed with one or two stout, solid spines nd a cluster of smaller, solid spines at the apex. *Philaenus trimaculatus* F.B.W. pl. 2, fig. 10) is the common three-spotted Frog-hopper of New Zealand, prettily iarked in green and reddish-brown; *Cercopis jactator* F. B. W. is a larger and arer species. The commonest forms in Australia belong to the genus *Philagra* fig. Q22), and are of a dull brown colour, with the head produced forwards

like a snout; these insects live chiefly on she-oaks (*Casuarina*). Australia also possesses two interesting genera of the subfamily Machaerotinae, or tube-forming cercopids, viz. *Pectinariophyes* and *Polychaetophyes*, in which the larvae form delicate tubes (fig. Q23) attached to the stems of eucalyptus saplings; they live in their own froth inside these tubes, and the last larval stage closely resembles a true pupa.

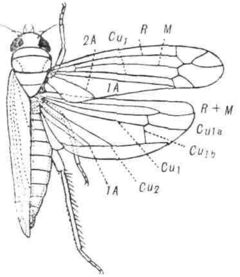


FIG. Q26. *Typhlocyba australis* Frogg., the Yellow Apple Leaf-hopper, Australia and New Zealand (introd.). Fam. Jassidae, subfam. Typhlocybinae. Lettering as in fig. A8, p. 22. Length 3 mm. [*R. J. T. del.*

Family 29. **Jassidae (Cicadellidae)** (Leaf-hoppers) [Aus. 200, N.Z. 52]. This immense family contains a large number of species in both countries, only a fraction of them having so far been studied. Most of the forms are small and inconspicuous; on account of the immense numbers in which they occur, they do a great deal of damage in the aggregate, though the individual punctures which they make on the leaves of plants are often not noticeable. In America they are known as "sharp-shooters" on account of the way in which they jump when disturbed. The family is recognized by the dilated or broadened cheeks, and by the possession of a double row of spines beneath the hind tibiae (feebly developed only in the Megophthalminae and Cephalelinae); these spines are not solid, as in Cercopidae, but are articulated on swollen bases. The group contains many diverse forms, and has already been split up by some authors into a number of separate families.

The Cicadellinae contains small species with the ocelli dorsally placed. The chief genus is *Tylozygus*, found in both countries. *T. cassiniae* Myers (fig. Q24) is common on *Cassinia* on the sea-coast of New Zealand; it is pale olive-brown, with whitish streaks and spots. *Vulturnus* contains numerous Australian species.

The small subfamily Paropiinae or Megophthalminae, with abnormally shaped heads and feebly armed legs, is only represented by *Paropia* (*Megophthalmus*) and two other genera in Australia, and by two species belonging to a new genus in New Zealand.

The Jassinae are a large group of small forms having the ocelli on the border of the vertex or on the margin between vertex and frons, and the venation normal. *Xestocephalus* and *Deltocephalus* are represented in both countries, *Tartessus*, *Nephotettix* and many other lesser genera in Australia, and *Euscelis* and *Phlepsius* in New Zealand. *Tharra* is peculiar to Australia and Fiji.

The peculiar Cephalelinae have a very elongate head and feebly spinose legs; the tegmina are leathery with the venation obliterated. *Paradorydium* and *Cephalelus* occur in both countries. *C. hudsoni* Myers (fig. Q25) is found on the Jointed Rush (*Leptocarpus*) in New Zealand.

The Typhlocybinae have the ocelli absent or vestigial, and the main veins arising separately and not branched distally. This group includes the widespread genera *Dicraneura*, *Erythroneura* and *Typhlocyba* found in both countries. The bright yellow *T. australis* Frogg. (fig. Q26) was first found on apples in New South Wales, but has now become a very serious pest of apple orchards in New Zealand.

The Bythoscopinae are a large group having the ocelli placed ventrally on the frons. The well known genera *Bythoscopus* and *Idiocerus* occur in both countries, while *Eurinoscopus* and *Agallia* contain other Australian species of

small size. *Ipo* is a genus of small, broadly wedge-shaped forms with very wide heads, found in Australia. The most striking of the Australian forms are the much larger species of the *Eurymela* group of genera, comprising *Eurymela*, *Eurymeloides* and *Eurymelops*. They are handsome, wedge-shaped species, superficially resembling Cercopidae, living in colonies upon the green branches of eucalyptus saplings, and generally attended by ants. The general colouring is steel-blue or black, marked with white, cream, yellow or red. *Eurymela rubrovittata* A. & S. (pl. 11, fig. 13), is one of the handsomest species. *E. bicolor*

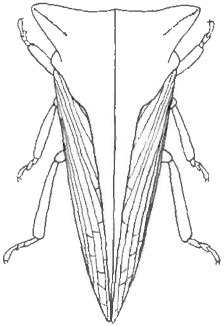


FIG. Q27. *Sextius virescens* Fairm., the Green Tree-hopper; Australia. Fam. Membracidae. Length 8.5 mm. [*A. Tonnoir del.*

Burm. has a black head and thorax, red abdomen, dark steely tegmina with the basal third red, hindwings brownish. *E. distincta* Sign. has two whitish oval blotches on the tegmina and the hindwings purple. All these species expand an inch or more. *Eurymeloides pulchra* Sign. (pl. 12, fig. 22) is a smaller, dark brown species with two narrow whitish bands crossing the tegmen.

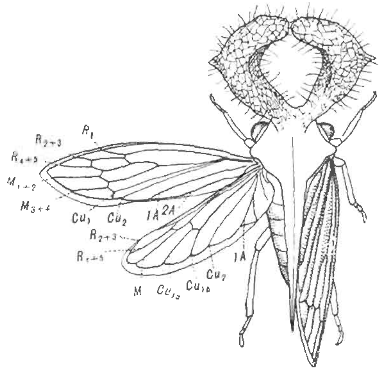


FIG. Q28. *Lubra regalis* Gdg., Australia. Fam. Membracidae. Length 7 mm. Lettering as in fig. A8, p. 22. See remarks on p. 142 (fossils). [*A. Tonnoir del.*

The Ledrinae are a peculiar group of large, brownish species with very prominent, flat, leaf-like head, often concave beneath, the ocelli placed dorsally, well away from the anterior margin of the head, the venation very complete. The principal Australian genera are *Ledra* and *Ledropsis*. The allied Stenocotinae are peculiar to Australia, and only differ in having the ocelli in pits on the angular margin of the head. Their larvae are very flattened, and are found on the bark of large trees. *Stenocotis planiuscula* Stal. and *St. caudata* Walk. (pl. 12, fig. 23) are the best known species.

Family 30. **Membracidae** (Tree-hoppers) [Aus. 40, N.Z. 0]. These bizarre insects may be at once recognized by the vertically placed head, with genae not dilated and ocelli placed between the eyes, and by the hypertrophied pronotum, which is generally prolonged backwards over the body so as more or less to hide the scutellum, and is often otherwise enlarged and ornamented. The larvae usually sit in rows along the twigs of trees and shrubs, and are attended by ants, which collect the sweet secretion or honey-dew discharged by them. Both larvae and adults have great jumping powers.

The family is absent from New Zealand, but well represented in Australia. Most of the species have the pronotum armed with a pair of dorsal horns or protubrances, as in the genera *Sertorius*, *Sextius*, *Eufairmairea* and *Daunus*. *Sextius virescens* Fairm. (fig. Q27) is the common green tree-hopper found on the Black Wattle (*Acacia decurrens*). *Eufairmairea fraterna* Dist. (pl. 11, fig. 14) is a fine dark brown species with bluntly-tipped, thorn-like dorsal processes. *Lubra regalis* Gdg. (fig. Q28) has remarkable, broad, laterally compressed, dorsal horns forming a complete circular arch. The species of *Acanthucus*, of which the commonest is *A. trispinifer* Fairm., have three dorsal projections. *Eutryonia monstrifera* Walk. has a single median process of bizarre form, transversely dilated at apex. *Terentius* and *Dingkana* have no dorsal processes, while *Eufroggattia* and *Porcorhinus* lack the usual posterior process of the pronotum. In all the Australian species the tegmen has an ambient vein and coriaceous border, as in the Cicadas.

Superfamily XIII. FULGOROIDEA

This superfamily contains a large number of very diverse forms, all of which are united by the form of the middle and hind coxae, the presence of a small hard piece or *tegula* between the base of the tegmen and the lateral angle of the pronotum, and by the two anal veins on the clavus generally forming a Y-vein. The ocelli are usually present and placed in the cavities of the cheeks. Fifteen families are known, of which all except three, the Tettigometridae, Achilioxiidae and Acanaloniidae, occur in Australia, giving a total of about 240 species. In New Zealand the twenty-two native species belong to the families Cixiidae, Delphacidae, Derbidae, Dictyophoridae and Achilidae; but species of Flatidae and Ricaniidae have been introduced from Australia. All the species are strong jumpers, and are generally termed Plant-hoppers. The larval forms develop tail-processes, or exude white, flocculent material around the anus. The twelve families found in Australia may be distinguished by the following Key*:—

1. Ocelli three — Fam. 31. CIXIIDAE (part)
   Ocelli two or none — 2
2. Hind tibiae with a movable spur at apex. — Fam. 32. DELPHACIDAE
   Hind tibiae without a movable spur at apex. — 3
3. Posterior angle of mesonotum divided off by a groove or line. — Fam. 33. TROPIDUCHIDAE
   Posterior angle of mesonotum not so divided off. — 4
4. Tegmina folded flatly, or nearly so, when at rest, and partially overlapping. — Fam. 38. ACHILIDAE
   Tegmina held roof-wise, not overlapping. — 5
5. Anal area of hindwing reticulate; lateral ridges of face continued on to clypeus. — Fam. 36. FULGORIDAE
   Anal area of hindwing seldom reticulate, or, if so, lateral ridges of face not continued on to clypeus. — 6
6. Face transverse, or nearly as long as wide. — Fam. 37. EURYBRACHIDAE
   Face distinctly longer than wide. — 7

*Adapted from F. Muir.

7.	Tegmen with a definite precostal area, usually crossed by numerous veinlets.	8
	Tegmen with precostal area absent or very small, without veinlets; rarely coriaceous.	10
8.	Clavus granulate.	Fam. 42. FLATIDAE
	Clavus not granulate.	9
9.	Head nearly as wide as, or wider than, pronotum.	Fam. 41. RICANIIDAE
	Head narrower than pronotum.	Fam. 40. LOPHOPIDAE
10.	Tegmina coriaceous, usually more or less convex, often shortened.	Fam. 39. ISSIDAE
	Tegmina not coraceous, neither convex nor shortened.	11
11.	Last segment of labium short, about as long as wide.	Fam. 34. DERBIDAE
	Last segment of labium longer than wide.	12
12.	Sides of clypeus keeled.	Fam. 35. DICTYOPHORIDAE
	Sides of clypeus not keeled (median ocellus absent).	Fam. 31. CIXIIDAE (part)

In using the above Key the term "face" is to be understood as including all the ventral frons down to the clypeus.

Family 31. **Cixiidae** [Aus. 25, N.Z. 17]. These are amongst the most primitive of Fulgoroids, and are the only ones in which all three ocelli are sometimes found, the median one being carried on the frontal ridge between

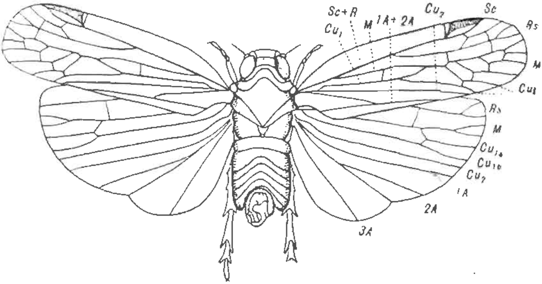


FIG. Q29. *Koroana helena* Myers, New Zealand. Fam. Cixiidae. Expanse of wings 10.5 mm. Lettering as in fig. A8, p. 22. See remarks on p. 142 (fossils). [*A. Tonnoir del.*

the eyes. The commonest genera are *Koroana* (fig. Q29) in New Zealand, *Oliarus* both there and in Australia. *O. asaicus* Kirk. occurs around Sydney, and *O. oppositus* Walk. in New Zealand. The larvae are found in ants' nests.

Family 32. **Delphacidae** [Aus. 52, N.Z. 6]. These are mostly very small insects easily recognized at once by the large mobile spur at the end of the hind tibiae. Most of the species belong to the genus *Delphacodes*. The most notorious species is the Sugar-cane Hopper, *Perkinsiella saccharicida* Kirk. (fig. Q31) a native of N. Queensland, which was accidentally introduced into the Hawaiian plantations, and did immense damage until it was controlled by the introduction of its natural enemies. *Micromasoria caelata* F.B.W. (fig. Q30) New Zealand species.

Family 33. **Tropiduchidae** [Aus. 5, N.Z. 0]. The Australian species of this family are confined to Queensland, and include the beautiful and delicately formed *Ossa venusta* Kirk. and *O. formosa* Kirk.

Family 34. **Derbidae** [Aus. 30, N.Z. 1]. The species of this family are mostly tropical or subtropical; they are all beautiful insects, many with a delicate colour pattern of yellow, brown, or cream-colour on the tegmina, and having a rather specialized venation. The New Zealand species is *Eocenchrea*

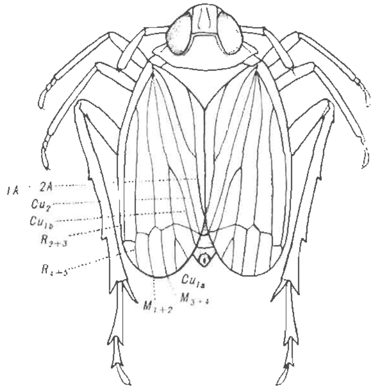


FIG. Q30. *Micromasoria caelata* F.B.W., New Zealand. Fam. Delphacida Length 4.5 mm. Note the movable spurs on hind tibiae. Lettering as i fig. A8, p. 22. See remarks on p. 142 (fossils). [*A. Tounoir de*

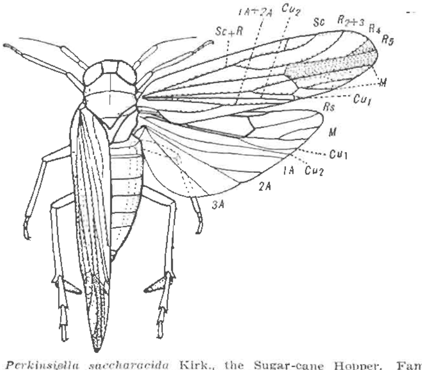


FIG. Q31. *Perkinsiella saccharacida* Kirk., the Sugar-cane Hopper. Fam. Del phacidae. Length of forewing 5 mm. Note the movable spurs on hind tibiae Lettering as in fig. A8, p. 22. See remarks on p. 142 (fossils). [*A. Tounoir de*

maorica Kirk. (pl. 12, fig. 24); it may be beaten from the undersides of tree fern fronds. The commonest Australian species is the pretty *Rhotana chrysono* Kirk. (fig. Q32) with rather broad, yellowish wings; it may be beaten in number from trees or bushes near water. The genus *Zoraïda*, containing several Aus tralian species, has exceedingly long, narrow wings, but the abdomen is ver short.

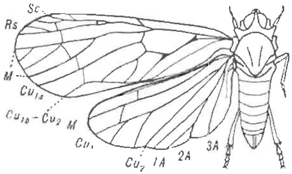


FIG. Q32. *Rhotana chrysonoë* Kirk., Australia. Fam. Derbidae. Length of body 2.5 mm. Lettering as in fig. A8, p. 22. See remarks on p. 142 (fossils).

Family 35. **Dictyophoridae** [Aus. 8, N.Z. 1]. In this family the wings are rather narrow and the head is prolonged greatly forward. Five of the Australian species belong to the genus *Thanatodictya*, *T. hebe* Kirk. being the best known. *T. tillyardi* Myers (pl. 2, fig. 11) recently discovered near Nelson, is the only known New Zealand species.

Family 36. **Fulgoridae** [Aus. 15, N.Z. 0]. Though not as large as the species of this family found in other countries, the Australian representatives are of fair size, mostly expanding from 1 to 1½ inches. The clavus is open distally, running the full length of the wing, and carries numerous cross-veins between the anal veins. Of these, the six beautiful species of *Desudaba* are the best known. *D. maculata* Dist. (pl. 11, fig. 15) has the tegmina a dark brown colour with numerous large spots, and the bases of the hindwings a brilliant crimson; it expands about 1½ inches. *D. psittacus* Walk. is somewhat smaller, with a green abdomen, unspotted tegmina and less crimson on the hindwings. *Eurinopsyche doddi* Dist. (pl. 12, fig. 25) is a peculiar brownish species with a projecting process in front of the head, like an elongated snout. All the species come from Queensland, except *Eurysthenus dilatatus* Wwd., which is found in Western Australia around Perth.

Family 37. **Eurybrachidae** [Aus. 28, N.Z. 0]. The members of this family are broad, squat insects of fairly large size and mottled brown and orange colouration, peculiar to Australia, where they live on the trunks of eucalyptus trees.

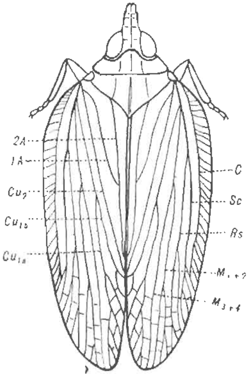


FIG. Q33. *Lophops saccharicida* Kirk., Australia. Fam. Lophopidae. Length from tip of snout to apex of tegmen 12 mm. Lettering as in fig. A8, p. 22. See remarks on p. 142 (fossils). [*A. Tonnoir del.*

Most of the species belong to *Eurybrachys* and *Platybrachys*; the species have been badly described, and are much in need of revision. *P. leucostigma* Walk. is common around Sydney.

Family 38. **Achilidae** [Aus. 14, N.Z. 1]. This family is peculiar in having the tegmina folded flatly when at rest and partially overlapping; the clavus is rather short, ending up little beyond half-way along the tegmen, and making a distinct angle with it. The bright red *Achilus flammeus* Kby. (pl. 11, fig. 17) is the best known Australian species. The only New Zealand species is *Agandecca annectens* F. B. W.

Family 39. **Issidae** [Aus. 20, N.Z. 0]. This family contains dull-coloured species, mostly found in Queensland, with peculiar tegmina of tough consistency, often shortened or convex. The principal genera are *Issus*, *Lollius*, *Gelastissus*, and *Chlamydipteryx*.

Family 40. **Lophopidae** [Aus. 1, N.Z. 0]. The well known *Lophops saccharicida* Kirk. (fig. Q33), a prettily marked species with the tegmina yellowish-brown with darker stripes, is the only recorded Australian species; it is found in Queensland on sugar-cane and grasses.

Family 41. **Ricaniidae** [Aus. 9, N.Z. 0]. The only common species is *Scolypopa australis* Walk. (fig. Q34 and pl. 12, fig. 26) the Passion-vine Hopper, which sometimes does considerable damage to passion-vines. It sits in rows along the stems with the wings forming a broad triangle; the tegmina are hyaline, heavily barred along costal and distal margins with black. This species

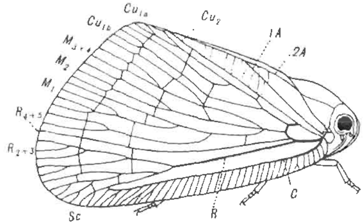


FIG. Q34. *Scolypopa australis* Walk., the Passion Vine Hopper, Australia and New Zealand (introd.). Fam. Ricaniidae. Total length 10 mm. (See also *pl. 12, fig. 26*). Colour-pattern omitted. Lettering as in fig. A8, p. 22. See remarks on p. 142 (fossils). [*R. J. T. del.*

has been accidentally introduced into the North Island of New Zealand, in parts of which it now exists on all the native vegetation in countless swarms, besides doing damage to orchards.

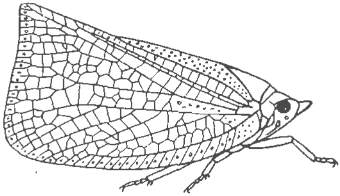


FIG. Q35. *Siphanta acuta* Walk., the Green Eucalyptus Hopper, Australia and New Zealand (introd.). Fam. Flatidae. Total length 9 mm. (See also pl. 6 fig. 8). Colour-pattern (pale venation on opaque green tegmen) omitted. [*R. J. T. del.*

Family 42. **Flatidae** [Aus. 40, N.Z. 0]. These graceful insects are the most highly evolved of all Fulgoroids. Their broad triangular tegmina, generally opaque and coloured, are folded closely against the body so as to form a very high roof over it. The principal Australian genera are *Siphanta*, *Euphanta* and *Sephena*. The bright green *Siphanta acuta* Walk. (fig. Q35 and pl. 6, fig. 8)

is the commonest species; it feeds on the leaves of eucalypts. This species is common in some parts of New Zealand, where it has been accidentally introduced. *Colgar peracuta* Walk. is a fairly common, pale green species with a pink border to the tegmen. Another species of a bluish grey colour, *Sephena cinerea* Kirk. (pl. 6, fig. 9), has also got into the North Island of New Zealand, and is now very abundant; it has been proved to carry fireblight (*Erwinia amylovora*) amongst apple and pear trees.

Division *STERNORRHYNCHA*

In this division are placed *only small, highly specialized forms, in which* the venation is reduced, with never more than six veins ending around the distal half of the forewing, which is seldom of true tegminous type; the hindwings are much reduced, with *R*, *M* and Cu_1 unbranched. The antennae appear to be more primitive than in the Auchenorrhyncha, being clearly segmented and possessing up to 25 segments. The part of the head capsule carrying the beak is detached from the rest and appears as if arising from between the forelegs. The tarsi never have more than two segments. There are four families, which are best arranged into two superfamilies as follows:—

Tarsi with two segments, the basal segment sometimes reduced, and with two claws; wings, when present, four in number. XIV. PSYLLOIDEA
Tarsi with only one segment and a single claw; males with only the forewings present; females always wingless. XV. COCCOIDEA

Superfamily XIV. PSYLLOIDEA.

The three families comprising this group may be easily distinguished as follows:—

1. Jumping insects, with femora thickened; empodia present, bilobed. Fam. 43. PSYLLIDAE
   Non-jumping insects, with slender femora; empodia, if present, not bilobed. 2
2. Wings opaque, whitish; body covered with meal; the two tarsal segments nearly equal in length; empodium present, in the form of a pad or spine. Fam. 45. ALEURODIDAE
   Wings transparent, sometimes coloured; body not mealy; tarsi with the basal segment sometimes much reduced; empodium greatly reduced or absent. Fam. 44. APHIDIDAE

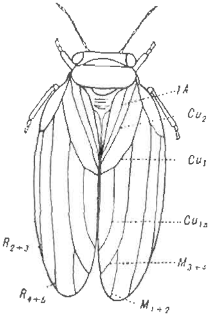


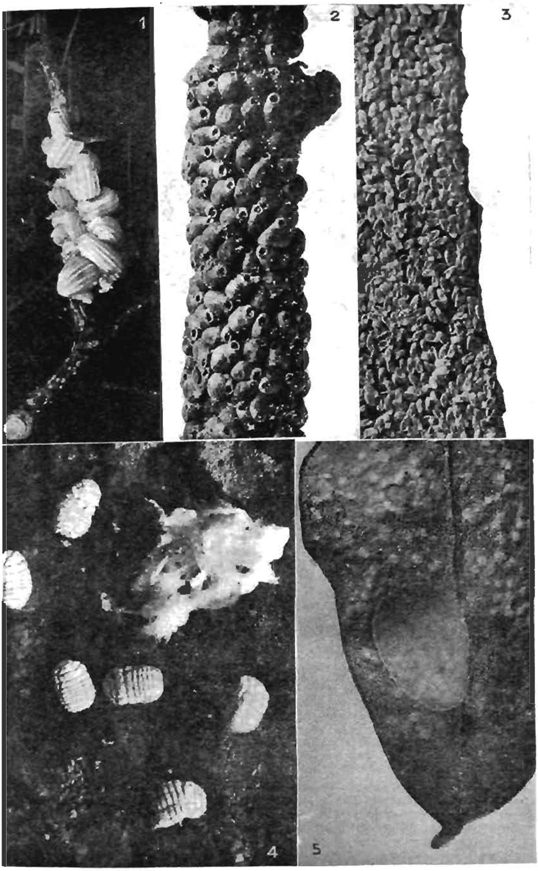
FIG. Q36. *Rhinocola fuchsiae* Mask., New Zealand. Fam. *Psyllidae*. Length to apex of tegmen 2 mm. Lettering as in fig. A8, p. 22. See remarks on p. 142 (fossils). [*A. Tonnoir del.*

Family 43. **Psyllidae** (Jumping Plant-lice, Lerp-insects) [Aus. 80, *N.Z.* 6]. In both countries this family takes the place of the true Plant-lice or Aphididae, their larvae clustering in immense numbers on the young foliage of eucalyptus, wattles and other plants. The larvae of many of the species secrete waxy tests or scales, or produce galls on leaves. A large number of the Aus-

Plate 13

HEMIPTERA

1. *Icerya purchasi* Mask., the Cottony Cushion Scale, Aus. and N.Z.; females and young on a twig of wattle (Acacia), (x 1.3).
2. *Eriococcus coriaceus* Mask., Blue-gum Scale, Aus.; female scales (x 2.7).
3. *Eriococcus coriaceus* Mask.; male tests (x 2.7).
4. *Coelostomidia zealandica* Mask., Native Mealy-bug of N.Z., showing six females, with mass of white fluffy exudation covering eggs on upper right hand portion, and a batch of uncovered eggs on lower left hand portion of photograph (x 1.3).
5. *Ctenochiton viridis* Mask., N.Z. (x 2).



W. C. Davies photo.

HEMIPTERA

tralian species are associated with eucalypts; amongst these we may mention the well known Sugar-lerp insect, *Spondyliaspis eucalypti* Dobson; the sweet, waxy secretion of this and allied species is collected and eaten by the aboriginals, like manna; *Rhinocola corniculata* Mask. and *Rh. eucalypti* Mask., the latter also found on introduced gum-trees in New Zealand; *Thea opaca* Frogg., whose larvae live under the bark, and are attended by ants who gather their honey-dew; and the beautiful rose-red *Creiis longipennis* Walk. (pl. 11, fig. 18), one of our largest species, found in Eastern Australia and Tasmania. Wattles are often badly affected with small native species of *Psylla*, of which the tiny yellow *Ps. acaciae-baileyanae* Frogg. is very common around Sydney on the Cootamundra Wattle (*Acacia baileyana*), and has also been introduced into New Zealand. Another species, *Ps. sterculiae* Frogg. known as the "Star-psylla", is found on the kurrajong-tree (*Brachychiton*), which is also affected by a second species, *Tyora sterculiae* Frogg. Native fig-trees are the hosts of two species of *Mycopsylla*. The genus *Trioza* contains handsome species found both in Australia and New Zealand on various native plants. *T. eucalypti* Frogg. and *T. carnosa* Frogg. both form galls on the leaves of eucalypts: the former occurs in New Zealand also. *T. casuarinae* Frogg. has a curious elongated larva, and lives on the she-oak (*Casuarina*). The species of *Cardiaspis* form delicate, reticulate or shell-like tests of great beauty. The commonest native New Zealand species is *Rhinocola fuchsiae* Mask. (fig. Q36) found on the Tree Fuchsia (*Fuchsia excorticata*).

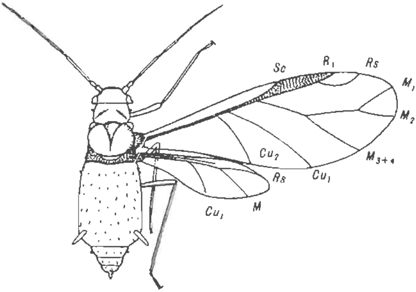


FIG. Q37. *Aphis coprosmae* Laing, the Native Aphis of *Coprosma rigida*, New Zealand. Length of body 1.5 mm. Lettering as in fig. A8, p. 22. See remarks on p. 142 (fossils). [*A. Tonnoir del.*

Family 44. **Aphididae** (Plant-lice) [Aus. 0, N.Z. 1]. Small, soft-bodied insects living in colonies on plants and trees; eyes prominent, antennae with 3-7 segments, the terminal one filamentous, beak 3-segmented; legs long, tarsi 2-segmented but basal segment often very short; abdomen often with a pair of *cornicles* or siphons projecting from the fifth abdominal segment. Winged forms with forewing much larger than hind, venation consisting of a stout *principal vein* from which *1A*, Cu_1, *M* and *Rs* arise posteriorly in turn from the base outwards; all veins simple except *M*, which is often 2-3 branched; hindwing with at most only three veins, *Rs*, *M* and Cu_1, all simple, and a remnant of *Sc*.

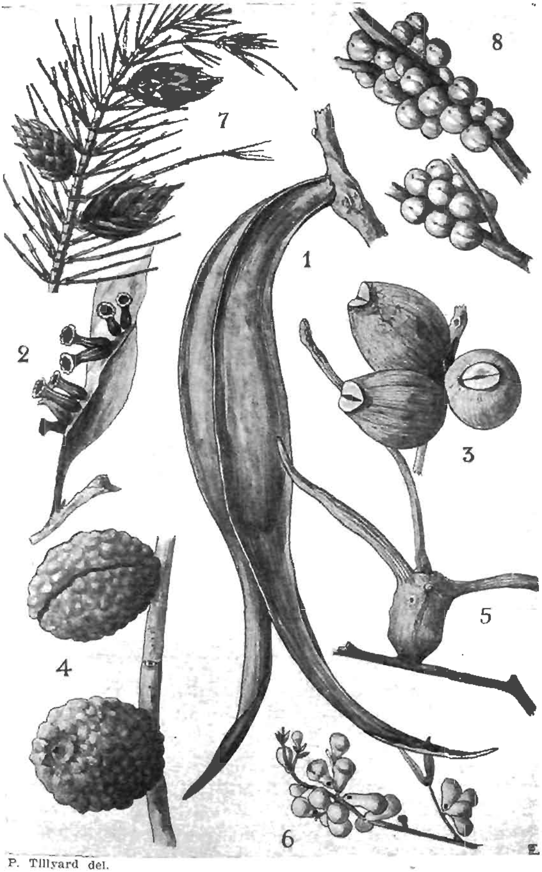
This family is remarkable for the production of four distinct types of individuals, viz. (1) wingless, viviparous, parthenogenetic females, called *stem-mothers*, (2) migratory, winged parthenogenetic females, (3) wingless, oviparous, sexual females which only produce eggs after pairing with (4) sexual males, usually winged, sometimes wingless or mouthless. The usual life-history is as follows:—In the spring, wingless stem-mothers are produced from over-wintered eggs laid by sexual females after pairing with males; these stem-mothers crawl up to the young growing shoots of the host-plant, and produce at a rapid rate, viviparously, larval forms which soon form a colony and develop into wingless stem-mothers; a succession of such broods takes place rapidly throughout the

PLATE 14

AUSTRALIAN COCCID GALLS

All figures natural size except fig. 1

1. Gall of *Apiomorpha duplex* Schrader, ($\frac{2}{3}$ natural size).
2. Galls of *Apiomorpha pileata* Schrader, males.
3. Galls of *Apiomorpha pileata* Schrader, females.
4. Galls of *Apiomorpha strombylosa* Tepper.
5. Gall of *Apiomorpha munita* Schrader.
6. Galls of *Sphaerococcus pirogallus* Mask.
7. Galls of *Cylindrococcus spiniferus* Mask.
8. Galls of *Cryptes baccatus* Mask.



P. Tillyard del.

AUSTRALIAN COCCID GALLS

summer, often leading to very heavy infestations. At intervals during the summer, winged parthenogenetic females are also produced, which migrate to other host-plants and there produce similar colonies of wingless aphids. Finally, usually in the autumn, sexual forms are produced, and these pair, the females laying the eggs from which the stem-mothers of the succeeding spring are produced. In some cases, the species hibernates as wingless stem-mothers. Some species live on two different host-plants, one during the winter and one during summer; other species go underground, or produce galls within which the larvae live.

Many aphids produce an oily or waxy secretion, which may be used as a protective covering, as in the case of the Woolly Aphis. Most species also produce a sweet secretion known as *honey-dew*, which is exceedingly attractive to ants.

As already stated (p. 170), native species of this family are almost entirely unknown in Australia and New Zealand, their place being taken by the Psyllidae. Recently, however, a true native species, *Aphis coprosmae* Laing. (fig. Q37), has been found by A. Philpott on *Coprosma rigida* near Nelson, New Zealand; it has primitive 7-segmented antennae, very complete venation, and segs. 1-6 of abdomen fused together. This species lays large, dark grey, oval eggs in rows along the stem of the plant; these hatch in September, producing black larvae which develop into stem-mothers; winged forms have been taken in December and wingless forms again in March.

Unfortunately, numerous harmful species of aphids have been introduced into Australia and New Zealand through the agency of man, and these do a great deal of damage to vegetables, flowers, crops and fruit-trees, most of them having few or no natural enemies to check them. The following may be mentioned:—*Phylloxera vastatrix* Planch., the Vine-Scourge, now controlled by the use of resistant stock; *Schizoneura lanigera* Hausm. the Woolly Aphis of apple-trees, now being successfully controlled by the introduced Chalcidoid parasite *Aphelinus mali* Hans.; *Schizoneura ulmi* L. which crumples the leaves of elms; *Pineus strobi* Hartig, on *Pinus radiata*; *Aphis abietina* Walk. which is killing off spruce (*Abies*) in many parts of New Zealand; *Aphis brassicae* L., the Cabbage Aphis; *Aphis gossypii* Glov., the Melon Aphis; *Aphis nerii* Fons., on oleander; *Aphis bakeri* Cowen damaging the flower-heads of red clover in New Zealand; *Aphis persicae-niger* Smith, the Black Peach Aphis; *Macrosiphum rosae* Reaum, the Rose Aphis; *M. solanifolii* Ashm. on potatoes; *M. granarium* Kby. on grasses and cereals; *Myzus cerasi* Fabr. on cherries and plums; *M. persicae* Sulz. on peaches; *Toxoptera aurantii* Fons. on citrus trees; and *Pemphigus populi-transversus* Riley, which forms galls on the leaf-stems of poplars in New Zealand. The Banana Aphis, *Pentalonia nigronervosa* Coquerel, transmits the virus of Bunchy-top disease in bananas, which is causing heavy losses in Australia.

Family 45. **Aleurodidae** (White-flies, Snow-flies) [Aus. 8 N.Z. 7]. These tiny insects are remarkable for their short, broadly rounded wings, usually covered with a fine white meal, closely resembling that found on the Coniopterygidae (Neuroptera Planipennia) with which they might be confused by beginners. The venation is greatly reduced, the forewing having only three simple veins, R_1, Rs and Cu_1. The tibiae carry a set of short spines distally. The life-history is highly specialized, the eggs being laid in a mass on the underside of leaves, and the larvae forming oval tests, within which they later on change into a true resting-stage or pupa. Both sexes are winged, and are usually disturbed in numbers, as they congregate together. Maskell has described eight species from Australia and seven from New Zealand; most of these, however, were named from the larval tests, found on the leaves of various native plants, e.g. *Tetraleurodes stypheliae* Mask. on *Styphelia*, *Aleurocanthus banksiae* Mask. on Bottle-brushes. *Asterochiton vaporarium* Wwd., the Greenhouse White-fly, is a common introduced species, which damages greenhouse plants.

Superfamily XV. COCCOIDEA.

(Scale Insects, Mealy Bugs).

The members of the single family comprising this group are undoubtedly the most highly specialized of all Hemiptera. The difference between the sexes is most marked, the females being comparatively large, stout-bodied, wingless insects, while the males are very much smaller, slender-bodied and delicate creatures with a single pair of gauzy wings folded flatly one above the other, and having at most only two veins, R and M, with a remnant of Sc. Some of the species live free

(Mealy-bugs), others in galls in plants (Apiomorphinae), but the great majority form hardened coverings or *scales*, the form of which differs very greatly in the two sexes. The females of the scale-forming species become fixed early in larval life, and lose their antennae and legs; the only part of the head-capsule remaining chitinized is the detached portion carrying the beak and tentorium; the males, however, undergo a very compete metamorphosis, with two larval instars, the second of which often closely resembles a true pupa.

Family 46. **Coccidae** (Scale Insects, Mealy Bugs) [Aus. 330, N.Z. 114]. Australia and New Zealand appear to be the headquarters of this large family, which is divided into eight subfamilies, all of which occur in Australia.

The Margarodinae are a group of primitive Mealy-bugs of medium to large size, the females measuring up to an inch in length in some species, and having well developed legs and clear segmentation. The males are very beautiful insects measuring up to half-an-inch in expanse, with large, glossy forewings furnished with a very strong vein along the costal margin, and carrying at the end of the body two long filaments or a large bundle of fine, white filaments resembling spun glass. This group is represented in Australia by the fine genus *Callipappus*. The Eastern Australian *C. australis* Mask. (pl. 6, fig. 10) and the allied Western Australian *C. westwoodi* Guer. have robust males of a reddish colour, with the wings a lovely rose-pink; they are known as Bird-of-Paradise Flies. In New Zealand three endemic genera are found, of which the best known is *Coelostomidia*, with several species; *C. zealandica* Mask (pl. 13, fig. 4) is the commonest species, the females being found on or under the bark of native trees; in laying her eggs she exudes a great quantity of flocculent material which entirely covers both them and her own shrivelled body. The males resemble those of *Callipappus* but are much smaller, the abdomen ending in two long filaments or streamers.

The Monophlebinae are another group of large, primitive Mealy-bugs having their headquarters in Australia. Of the five endemic genera, the best known is *Monophlebus*. *M. crawfordi* Mask. is a well known species, the female being a huge, broadly oval, flattened insect of dull orange and purplish colour, with very clear segmentation, and usually found on the trunks of eucalypts. The eggs are hidden under a mass of finely fluted wool. *Icerya purchasi* Mask. (pl. 13, fig. 1), the Cottony Cushion Scale or Fluted Scale, originally described from New Zealand, is found both there and in Australia on wattles (*Acacia*), *Pittosporum*, Kowhai (*Edwardsia*) and other shrubs. Accidentally introduced into California, it did immense damage to citrus orchards until it was exterminated by the introduction of the Australian Ladybird Beetle, *Novius cardinalis* Muls., which also controls it in New Zealand.

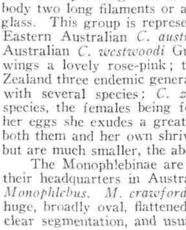


FIG. Q38. *Apiomorpha duplex* Schrader, female, dorsal view; Australia. Fam. Coccidae, subfam. Apiomorphinae. Length 30 mm. Below, end of abdomen, lateral view, dorsum to right. [*R. J. T. del.*

The Apiomorphinae (Brachyscelinae) are a remarkable group of gall-forming Coccids peculiar to Australia, more than 40 species being known, mostly comprised in the genera *Apiomorpha* (29 species) and *Opisthoscelis* (10 species). *Apiomorpha duplex* Schrader (pl. 14, fig. 1) forms the largest gall in the world; it is attached to the twigs of eucalypts, and is usually about three inches long, of a very graceful shape, consisting of a four-sided chamber with ridged edges continued as two elongated appendages; the enclosed female coccid (fig. Q38) has been measured up to 1½ inches in length. The males of *A. pileata* Schrader (pl. 14, fig. 2) form narrow urn-shaped galls often found in large clusters on leaves or twigs; the females make much larger, woody galls shaped like the conventional bishop's head in chess (pl. 14, fig. 3). *A. pomiformis* Frogg. forms a large gall shaped like a small apple on stunted gums in central and northern Australia; *A. strombylosa* Tepper (pl. 14, fig. 4) makes large, rounded, rugose galls resembling nutmegs; the galls of *A. munita* Schrader (pl. 14, fig. 5) resemble the fruit of *Lambertia*, but with three much longer processes. All the species of this genus live on eucalypts, as do also the species of *Opisthoscelis* and *Ascelis*, which make smaller galls. The genus *Frenchia* contains two species which form swollen galls with blunt, thorn-like processes on she-oaks (*Casuarina*).

The Idiococcinae are a peculiar group having neither anal tubercles nor antennae; some form tests and some galls. About 30 species are known from Australia, of which 20 belong to the genus *Sphaerococcus;* the best known is *S. pirogallus* Mask. (pl. 14, fig. 6) forming pear-shaped galls along the slender terminal twigs of tea-tree (*Melaleuca*). The genus *Cylindrococcus* contains four Australian species, of which *C. spiniferus* Mask. (pl. 14, fig. 7) forms large galls, resembling true cones, on the stems of she-oak (*Casuarina*).

The Dactylopiinae or Mealy-bugs are common both in Australia and New Zealand, the former country possessing nearly 100 species, the latter more than 30. Some of the genera secrete tests, becoming fixed in masses on stems of trees, and do not move about like the more typical genera *Dactylopius* and *Pseudococcus*. *Dactylopius coccus* Costa, the Cochineal insect, has been introduced into Australia to destroy prickly pear, but would attack only one species, *Opuntia monacantha*. The more recently introduced *D. tomentosa* Lam., however, will attack the pest pear, *Opuntia inermis,* and may yet prove the decisive factor in its control. *Antonina australis* Green is one of the few native beneficial species, as it lives on the roots of Nut-grass, a serious pest of gardens in Australia. The genus *Pseudococcus* contains 18 species in Australia, 8 in New Zealand, all typical Mealy-bugs, covered with white, flocculent secretion, and inhabiting numbers of native trees, including eucalypts, araucarias and wattles. *Pseudococcus calceolariae* Mask. is found in New Zealand on Native Flax (*Phormium*), Cabbage-tree (*Cordyline*) and calceolarias, and has spread to sugar cane in Hawaii. *Ps. adonidum* L. is a bad introduced pest of vineyards in New Zealand, while *Ps. maritimus* Ehr. and *Ps. comstocki* Kuw. are rapidly becoming very serious pests in apple and pear orchards; their control is a problem of great difficulty. The most abundant genus in Australia is *Eriococcus,* of which nearly 30 species are known; the commonest is *E. coriaceus* Mask. (pl. 13, figs. 2, 3) which infests the branches of gum-trees. It does little harm in Australia; but, when accidentally introduced into New Zealand, it killed off many thousands of acres of Blue Gum (*E. globulus*) until controlled by the introduced Australian Ladybird Beetle *Rhizobius*. Other important genera are *Rhizococcus* feeding on wattles and she-oaks, and *Asterolecanium,* of which an introduced species, the Oak Scale, *A. variolosum* Ratz. is doing serious damage to oaks in New Zealand.

The Tachardiinae or Lac-insects are represented by six Australian species, none of which have yet been used commercially. The resinous secretion, or lac, of the Indian species is used in India for making varnish. The females have a pair of tubular appendages on the back. *Tachardia decorella* Mask. and *T. australis* Frogg. are the best known species.

The Coccinae (Lecaniinae) are known as Soft Scales; nearly 60 species are recorded from Australia, and 20 from New Zealand. The principal genera are *Pulvinaria, Coccus (Lecanium), Saissetia, Ctenochiton* and *Inglisia,* all five of these genera occurring in both countries. *Ctenochiton viridis* Mask. (pl. 13, fig. 5) and other species of this peculiar genus are common in New Zealand. The curious, spherical galls of *Cryptes baccatus* Mask. (pl. 14, fig. 8) occur on wattles around Sydney. A number of introduced species are serious pests, such as *Ceroplastes ceriferus* Anderson, the Indian Wax-scale, *Saissetia oleae* Bern. the Black or Olive Scale on citrus trees, *S. hemisphaerica* Targ. on oleander, ferns, etc., *Eucalymnatus tesselatus* Sign. on palms, and *Coccus hesperidum* L., the Soft Brown Scale, on a large number of plants.

The Diaspinae or Hard Scales are abundant in both countries, no less than 115 being known from Australia, and over 30 from New Zealand. Most of them belong to the genera *Aspidiotus, Parlatoria, Lepidosaphes (Mytilaspis), Poliaspis, Leucaspis, Diaspis* and *Chionaspis*. *Leucaspis stricta* Mask. is common on New Zealand Flax (*Phormium tenax*) and other plants; it is an elongated, white scale. The worst of the introduced scale pests belong to this subfamily, and include *Aspidiotus perniciosus* Comst., the San José Scale; *Lepidosaphes ulmi* L. (=*Mytilaspis pomorum* Bouché), the Oyster-shell or Mussel Scale, both found on apple trees; *Aulacaspis rosae* Bouché, the Rose Scale; *Chrysomphalus aurantii* Mask., the Red Scale of orange; *Aspidiotus hederae* Vall. on oleander. The control of these pests costs both Australia and New Zealand a very large sum of money annually for spraying.

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CHAPTER XX

Order COLEOPTERA

(Beetles, Weevils)

THIS Order is the dominant one amongst existing insects, nearly 200,000 species having been described for the whole world, or about 42 per cent of the known insect-fauna. They form a very distinct and compact group, which can be at once recognized by the highly specialized form of the forewings; these organs are modified into *elytra* or covers which protect the membranous hindwings, and in most cases fit very closely backwards over the body of the insect. This character, together with the form of the prothorax, which is large and very distinct from the rest of

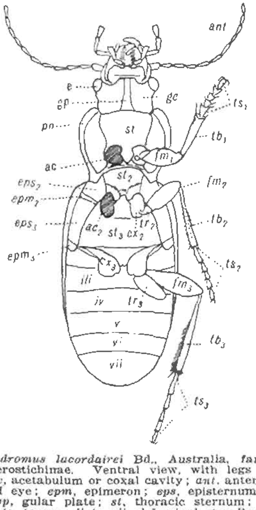


FIG. R1. *Catadromus lacordairei* Bd., Australia, fam. Carabidae, subfam. Pterostichinae. Ventral view, with legs of right side removed. *ac*, acetabulum or coxal cavity; *ant*, antenna; *cx*, coxa, *e*, compound eye; *epm*, epimeron; *eps*, episternum; *fm*, femur; *ge*, gena; *gp*, gular plate; *st*, thoracic sternum; *tb*, tibia; *tr*, trochanter; *ts*, tarsus; *ii to vii abdominal sternites; the suffixes* 1, 2, 3 indicate parts of the pro-, meso- and meta-thorax respectively. For details of mouthparts, see fig. R2. Length 32 mm. [*A. Tonnoir del.*

the thorax, and the holometabolous life-history, will suffice to distinguish a beetle from any other insect.

Characters. Beetles vary in size from minute species less than 1 mm. long up to very large forms. Most of them have a very hard cuticle, and many have the elytra beautifully fitted to the body and united along the middle line; in others, however, (e.g. Lampyroidea) there is little co-adaptation of the elytra to the body, and the cuticle is soft and feebly chitinized.

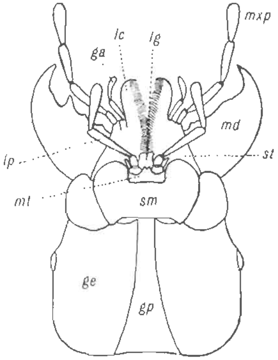


FIG. R2. Ventral view of mouth-parts of a Carabid, with mandibles open. *ga.* galea (two-segmented); *ge.* gena; *gp.* gular plate; *lc.* lacinia; *lg.* ligula; *lp.* labial palp; *md.* mandible; *mt.* mentum; *mxp.* maxillary palp; *sm.* submentum; *st.* stipes. [*A. Tonnoir del.*

H e a d of variable shape, frequently wider than long, with the *compound eyes* placed laterally, usually well separated from one another (sometimes closer together in males than in females); *ocelli* usually absent, though two are present in some Staphylinidae and one in most Dermestidae; *antennae* normally with eleven segments, of very variable shape and length. *Mouth-parts* (fig. R2) of normally mandibulate type, the mandibles hard and strongly formed, the maxillae generally complete, with usually four-segmented palp, galea and lacinia; the galea is sometimes divided into two distinct segments similar to those of the palp, and, in some cases is borne on a separate piece, the subgalea, divided off from the stipes; labium with usually three-segmented palpi (not always visible) and a complete or divided ligula, the mentum generally small or absent, the submentum* large; *gular plate* (*gp*) narrow, often constricted in middle, generally present except in Curculionoidea. A neck is seldom present.

T h o r a x composed of a large *prothorax* very distinct from the rest, and a *pterothorax*, composed of the more or less fused meso- and metathorax, which unites with the abdomen to form a continuous piece

*Usually called the "mentum" in systematic works on Coleoptera.

quite distinct from the prothorax. Owing to this, a beetle, when viewed dorsally, shows the three divisions of head, pronotum, and the rest of the body (usually covered by the elytra), instead of the three divisions usual in the Insecta; and consequently the term "thorax" is found to be frequently used in literature on Coleoptera when the prothorax alone, or even only the pronotum, is meant. The combined pterothorax and abdomen may conveniently be spoken of as the *after-body*. *Prothorax* consisting of a large, hard pronotum, usually much broader than the head, and entirely covering the ventrally placed pleura* and sternum; pleuron either divided into a large episternum and smaller epimeron, or else undivided; sternum usually a flat plate carrying two large acetabula or coxal cavities for the insertion of the forelegs. *Mesothorax* with the mesonotum covered by bases of elytra, with the exception of the scutellum, which can generally be seen as a small triangular plate behind the pronotum, separating the extreme bases of the elytra; *metathorax* with the metanotum usually entirely hidden beneath the elytra; the pleura and sterna of these two segments all ventral in position, the pleura* either divided into a larger episternum and smaller epimeron, or else undivided, the sterna carrying the acetabula or coxal cavities, which, however, frequently abut on to the pleura; hind coxal cavities

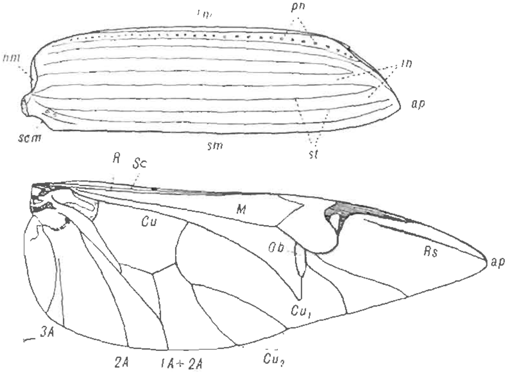


FIG. R3. Elytron (above) and hindwing (below) of *Catadromus lacordairei* Bd., Australia, fam. Carabidae. Length of elytron 21 mm.; *ap*, apex; *hm*, humeral margin; *in*, interval; *lm*, lateral margin; *pn*, punctures; *scm*, scutellar margin; *sm*, sutural margin; *st*, striae. Lettering of hindwing as in fig. A8, p. 22, except *Ob*, oblongum. [*A. Tonnoir del.*

also encroach on to first abdominal sternite. *Legs* generally strongly formed, the coxae variable in shape, the trochanters not divided, the femora stout and strong, the tibiae usually slenderer (stouter in burrowing forms), with or without spurs, the tarsi usually with five segments in the more archaic families, but sometimes reduced to four, more rarely to three only; tarsi usually ending in two sharp claws

*When undivided, the pleura are termed "parapleura" by Coleopterists. It should be noted that the mesepimeron (fig. R1) is separated from the middle coxal cavity by the *metasternum*, not by the mesosternum as usually figured.

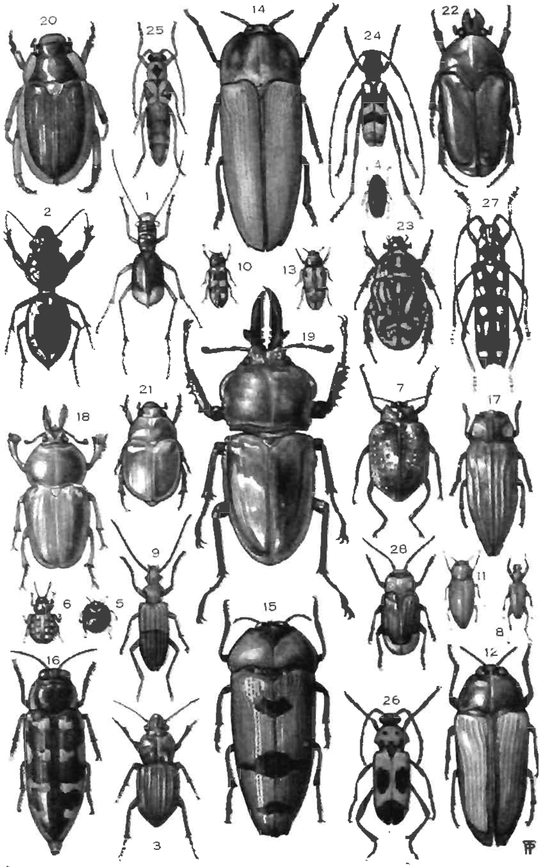
Plate 15

AUSTRALIAN COLEOPTERA

All figures natural size except figs. 5 and 6

1. *Megacephala australis* Chaud. (Fam. Cicindelidae).
2. *Carenidium spaldingi* Macl. (Fam. Carabidae).
3. *Notolestus sulcipennis* Macl. (Fam. Carabidae).
4. *Episcaphula nigrofasciata* Blkb. (Fam. Erotylidae).
5. *Orcus chalybeus* Bd. (Fam. Coccinellidae). (x 2).
6. *Pedilophorus gemmatus* Lea. (Fam. Byrrhidae). (x 1.5).
7. *Prophanes mastersi* Pasc. (Fam. Tenebrionidae).
8. *Aethyssius viridis* Bd. (Fam. Cistelidae).
9. *Agasma semicrudum* Newm. (Fam. Oedemeridae).
10. *Melobasis gratiosissima* Thoms. (Fam. Buprestidae).
11. *Melobasis metallifera* Hope. (Fam. Buprestidae).
12. *Stigmodera suturalis* Don. (Fam. Buprestidae).
13. *Stigmodera cyanicollis* Bd. (Fam. Buprestidae).
14. *Calodema regalis* L. & G. (Fam. Buprestidae).
15. *Calodema plebeja* Jord. (Fam. Buprestidae).
16. *Cyria imperialis* Don. (Fam. Buprestidae).
17. *Chrysodema aurofoveata* Guer. (Fam. Buprestidae).
18. *Lamprima latreilli* W.S.M. (Fam. Lucanidae), male.
19. *Phalacrognathus muelleri* Macl. (Fam. Lucanidae), male.
20. *Calloodes grayanus* Wh. (Fam. Scarabaeidae).
21. *Calloodes mastersi* Macl. (Fam. Scarabaeidae).
22. *Lomaptera yorkiana* Jans. (Fam. Scarabaeidae).
23. *Eupoecila australasiae* Don. (Fam. Scarabaeidae).
24. *Aridaeus thoracicus* Don. (Fam. Cerambycidae).
25. *Hesthesis ferruginea* Bd. (Fam. Cerambycidae).
26. *Purpuricenus angasi* Wh. (Fam. Cerambycidae).
27. *Glenea picta* Fabr. (Fam. Cerambycidae).
28. *Aesernia australasiae* Jac. (Fam. Chrysomelidae).

Plate 15



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AUSTRALIAN COLEOPTERA

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(reduced or absent in some forms), rarely with an empodium between them, never with pulvilli. *Spiracles*, one, two or even three pairs, the first pair placed well forward latero-ventrally beneath pronotum; when three pairs are present (Staphylinoidea), only seven pairs are found on abdomen.

W i n g s :—*Forewing* specialized as an elytron or hard, horny covering for the hindwing; this elytron seldom shows any signs of true venation, but is often pulverulent, downy, hairy or even scaly; it is frequently sculptured, either with a series of longitudinal grooves, called *striae*, separated by raised *intervals*, or with longitudinal rows of pits in the striae (punctate-striate), or with tubercles (tuberculate), or covered with a meshwork of ridges and hollows (reticulate, cancellate or clathrate), or granulate, shagreened or rugose all over. The elytron is attached to the side of the mesothorax by a definite hinge, and is generally convex and more or less subtriangular in form; the long outer side is called the *lateral margin* (fig. R3, *lm*) and the long inner side the *sutural margin* (*sm*); this latter usually has a narrow, shelf-like rim, and the rims of the two elytra fit closely one over the other, so that only a median line, the *suture*, separates them. On the inner side of the hinge, a short *scutellar margin* (*scm*) is generally more or less apparent

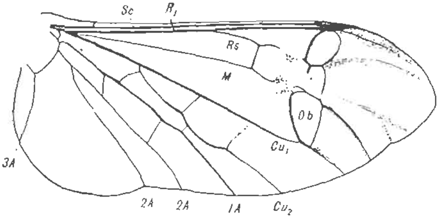


FIG. R4. Hindwing of *Omma stanleyi* Newm., fam. Cupidae. Lettering as in fig. A8, p. 22, except *Ob*, oblongum. [*R. J. T. del.*

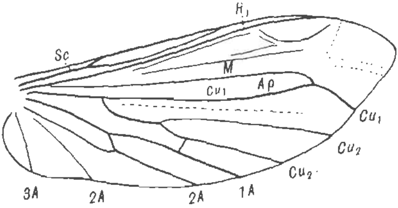


FIG. R5. Hindwing of *Metriorrhynchus* sp., fam. Lampyridae. Lettering as in fig. A8, p. 22, except *Ap*, apertum. [*R. J. T. del.*

while, in some forms, the basal part of the lateral margin is sharply marked off from the rest as a *humeral margin* (*hm*). In flight, the elytra are generally raised and held somewhat apart, allowing free play to the hindwings, which alone act as organs of propulsion in

flight. *Hindwing* remarkable in having a very peculiar form of venation, and with the apical portion nearly always capable of being folded in automatically; a few (Staphlyinoidea) have a double fold. Sc and R_1 run close together, sometimes more or less fused, just below the costal margin; a thickened pterostigmatic area can frequently be recognized above the apical portion of R_1. Rs very variable in form; its course, *branchings and amount of chitinization are greatly affected by the* apical infoldings. As regards the veins below Rs, there is at present a lack of agreement as to their homologies, but it seems almost certain that the first slender vein below Rs (fig. R4) is M, and the stout vein below it Cu_1. Handlirsch and Forbes interpret them thus, but d'Orchymont considers the upper vein to be M_{1+2} and the lower M_{3+4}. In any case, the important point is to notice the presence within the Order of two distinct types of venation, whose phylogeny has been beautifully worked out by d'Orchymont. In one of these (Adephaga), the wing possesses a closed cell, the *oblongum* (Ob) developed in relation to M at about two-thirds from the base; in the other (Polyphaga), this cell is absent, and is replaced by a formation called the *apertum*, (Ap) which is a long triangular cell, usually incomplete and open basally, formed between M anteriorly and Cu_1 posteriorly; in most forms of this type, M *is incompletely chitinized basally, and is called the returning vein*; in the Staphylinoidea the apertum is vestigial or absent, but M runs strongly to the wing-margin. Below the vein Cu_1 there are normally *no less than five longitudinal veins, which have to be allotted* between Cu_2 and the anal veins; $1A$ and $2A$ are usually simple, $3A$ forked, Cu_2 simple or forked. The most archaic types show one cross-vein from near base of Rs to M, two cross-veins below Cu_1, and one or two in the anal region. There are many reduction-forms from the apertum-type, down to small, narrow wings with a hairy fringe (e.g

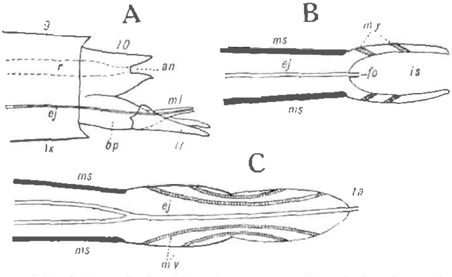


FIG. R6. A, lateral view of end segments and genitalia of a male Coleopteron of generalized type (diagrammatic). B, median lobe of same, enlarged, with internal sac retracted. C, the same, with internal sac exserted as in copulation; *an*, anus; *bp*, basal piece; *ej*, ejaculatory duct; *fo*, functional orifice; *is*, internal sac; *ll*, lateral lobe; *ml*, median lobe; *ms*, median strut; *my*, muscle; *r*, rectum; *ta*, transfer apparatus; 9-10, tergites; ix, ninth sternite. (Adapted from *Sharp* and *Muir*, *R. J. T.*).

Trichopterygidae) and with little or no venation; in many flightless forms the hindwings are quite absent and the elytra soldered together.

A b d o m e n :—In this Order considerable specialization of the segments occurs both at the base and apex of the abdomen. The first

tergite is present, together with the pleural region bearing the spiracle, but the first sternite is always absent. In many Polyphaga the second sternite is also absent as a distinct plate (possibly fused with the third). Thus, when the abdomen is viewed ventrally, the number of visible segments is either one or two less than the number visible dorsally or laterally; these are generally spoken of by systematists as the *ventral visible segments* and *lateral visible segments* respectively, and the term *first* or *basal visible ventral segment* indicates actually either the second or third sternite, as the case may be. We shall speak of *visible tergites* and *visible sternites* respectively, and the first visible sternite will be called the *basal visible sternite*, since it is never the true first sternite.

The terminal segments of the abdomen are highly modified, especially in the male. The eighth segment is complete, with tergite, sternite and membranous pleura carrying a pair of spiracles; the ninth and tenth segments are retracted within the eighth, and the tenth sternite is always absent. The female never has a primitive ovipositor, but the terminal segments are often much elongated and telescopic, forming a specialized type of ovipositor for the laying of eggs in soil, crevices of bark, etc. In the male, the genitalia are situated, as usually in the Insecta, between the ninth sternite and the proctiger or reduced tenth segment; normally they are entirely retracted, but in some groups a strongly chitinized *anal forceps* is to be seen projecting from the abdomen (e.g. Cistelidae, Phalidurinae). The complete male genitalia, or *aedeagus*, (fig. R6), when everted, is found to consist of a strongly

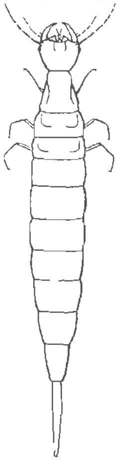


FIG. R7. Larva of large Dytiscid, New Zealand. Length 32 mm. [*R. J. T. del.*

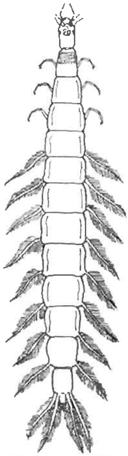


FIG. R8. Larva of *Macrogyrus* sp., Australia, fam. Gyrinidae. Length 20 mm. [*A. Tonnoir del.*

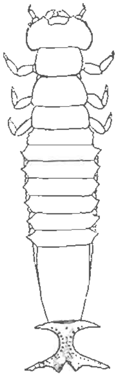


FIG. R9. Larva of *Ipsaphes bicolor* Oll., Australia, fam. Cucujidae. Length 22 mm. [*A. Tonnoir del*

built tube, called by Sharp and Muir the *tegmen,* consisting of a ring-like *basal piece* (*bp*) and a pair of lateral lobes* (*ll*); between the lateral lobes there projects the *median lobe* (*ml*), within which is an inverted *internal sac* (*is*); at the base of this sac is the minute opening of the *ductus ejaculatorius* (*ej*), i.e., the true *functional orifice* (*fo*) of the male genital organs; the median lobe is supported by two apodemes, the *median struts* (*ms*). During copulation, the internal sac is everted, so that the functional orifice is brought to the extreme apex of the aedeagus; generally a specially chitinized *transfer apparatus* (*ta*) is present around the orifice to assist in the transference of the sperms. In some cases the transfer apparatus is developed into a *flagellum*, or fine tube of considerable length, the ductus running to the very end of it. The above account only deals with the more primitive or *trilobe* type of Coleopterous genitalia; the number of modifications in the more specialized groups is very great and of considerable value in classification (see papers by Sharp and Muir).

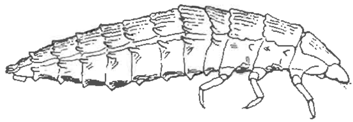


FIG. R10. Larva of *Metriorrhynchus* sp., Australia, fam. Lampyridae. Length [*A. Tonnoir del.*

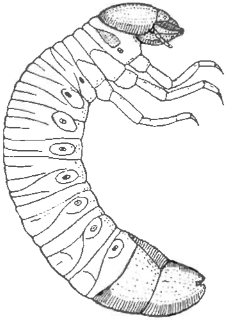


FIG. R11. Larva of *Pericoptus punctatus* Wh., New Zealand, fam. Scarabaeidae. [*R. J. T. del.*

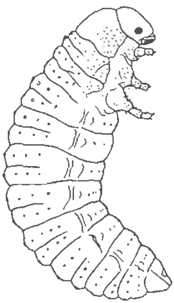


FIG. R12. Larva of *Paropsis* sp., Australia, fam. Chrysomelidae. Length 15 mm. [*A. Tonnoir del.*

In those cases in which the elytra do not completely cover the abdomen, the exposed apical segment (seventh or eighth) is hardened and is known as the *pygidium*. More rarely the preceding segment is also exposed and hardened; it is then called the *propygidium*.

Spiracles usually eight pairs. *Malpighian tubules* six or four.

*There is no evidence that these are homologous with the parameres of Hemimetabolous Orders.

Life History. The *eggs* of beetles are laid in all kinds of places, in many ways, and show considerable variation in form, though most of them are oval or pear-shaped and without sculpture. The duration of the embryonic period is known for only a few forms;

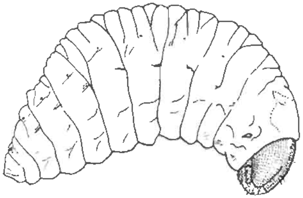


FIG. R13. Larva of *Chrysolophus spectabilis* Fabr., Australia, fam. Curculionidae, subfam. Curculioninae. Length 18 mm. [*A. Tonnoir del.*

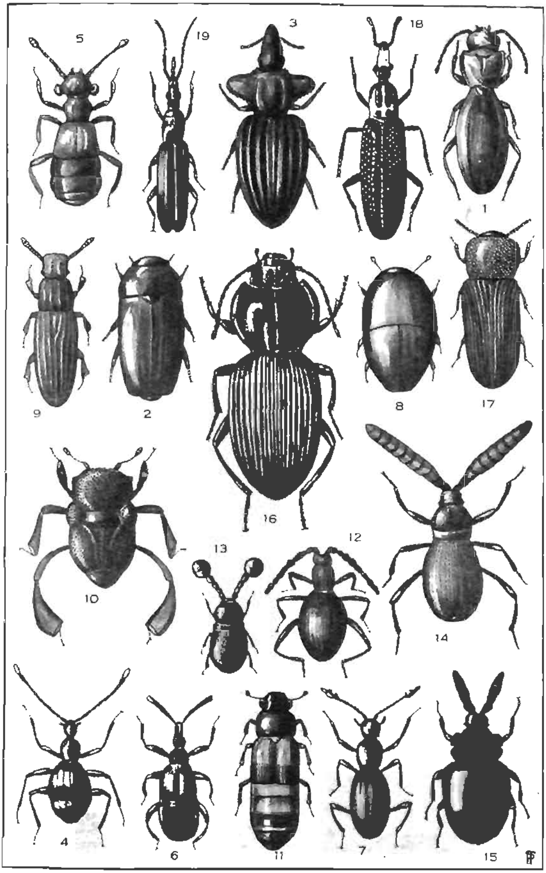
indeed, less is known about the life-histories of beetles than of any other of the larger Orders, and comparatively few complete life-histories of Australian or New Zealand species have so far been worked out. The *larvae* (figs. R7-13) are of various forms, but can be roughly classified into two distinct types, viz. active, predatory larvae (*caraboid type*) with well-developed thoracic legs, a prominent head, and more or less chitinization of the segments, and less active, often sluggish, grub-like larvae, chiefly feeders on vegetable tissues or decaying matter. The first of these two types is the more archaic; it is found in most of the families of Adephaga. Many of the older families of Polyphaga also possess this type of larva, but with the tarsi ending in a single claw instead of two; these families also exhibit a number of broader, flattened larval types which Handlirsch claims to be archaic Blattoid forms (e.g. Silphidae) but which are probably secondary adaptations from the original, elongate, caraboid type. From the true caraboid types it is easy to pass to the active, foraging types of more cylindrical or fusiform shape, with shorter legs and less prominent head, such as are to be found in Tenebrionoidea. The more specialized groups possess larvae of grub-like form, sometimes straight and cylindrical, sometimes with the body greatly curved (*melolonthoid type*, fig. R11); these may have short thoracic legs (Scarabaeoidea), or no legs at all (most Curculionoidea), or they may lose their legs in course of development. These latter grubs are of the true *vermiform type* (fig. R13). In most cases the young larva does not differ much from the full-grown larva; but in certain groups the phenomenon of *hypermetamorphosis* occurs, as in the Cantharidae. In such cases the young larva is of the active, caraboid type, and is called a *triungulin;* after the first moult, in correlation with a change of habit, it assumes a grub-like form.

The larvae of Coleoptera have at most nine complete abdominal segments, though the tenth is often present in a modified and reduced form, generally as a slender, protrusible end-piece furnished with small hooks, a useful aid in progression. Caraboid larvae also frequently possess a pair of segmented or simple processes at the end of the abdomen; these are true cerci, though apparently attached to the ninth segment owing to reduction of the tenth.

PLATE 16

AUSTRALIAN INQUILINE COLEOPTERA

1. *Illaphanus stephensi* Macl. (Fam. CARABIDAE). (length 1 mm.).
2. *Adelotopus castaneus* Cast. (Fam. CARABIDAE). (length 6 mm.).
3. *Nepharis alata* Cast. (Fam. CUCUJIDAE). (length 4 mm.).
4. *Leanymus mirus* Lea (Fam. PSELAPHIDAE). (length 1.4 mm.).
5. *Daveyia mira* Lea (Fam. PSELAPHIDAE). (length 1.3 mm.).
6. *Articerus foveicollis* Raff. (Fam. PSELAPHIDAE). (length 2.2 mm.).
7. *Heterognathus geniculatus* King (Fam. SCYDMAENIDAE). (length 2 mm.).
8. *Kodzwayia orientalis* Lea (Fam. TRICHOPTERYGIDAE). (length 0.7 mm.).
9. *Kershawia ruficeps* Lea (Fam. COLYDIIDAE). (length 4 mm.).
10. *Chlamydopsis agilis* Lea (Fam. HISTERIDAE). (length 4.5 mm.).
11. *Brachypeplus auritus* Murray (Fam. NITIDULIDAE). (length 4 mm.).
12. *Enasiba tristis* Oll. (Fam. PTINIDAE). (length 5 mm.).
13. *Hexaplocotes sulcifrons* Lea (Fam. PTINIDAE). (length 2 mm.).
14. *Paussoptinus laticornis* Lea (Fam. PTINIDAE). (length 3 mm.).
15. *Ectrephes formicarum* Pasc. (Fam. PTINIDAE). (length 2 mm.).
16. *Cardiothorax acutangulus* Bates (Fam. TENEBRIONIDAE). (length 17 mm.).
17. *Palorus entermiphilus* Lea (Fam. TENEBRIONIDAE). (length 2.5 mm.).
18. *Tretothorax cleistostoma* Lea (Fam. TENEBRIONIDAE). (length 11 mm.).
19. *Cordus hospes* Germ. (Fam. BRENTHIDAE). (length 7 mm.).



P. Tillyard and A. Tonnoir del.

AUSTRALIAN INQUILINE COLEOPTERA

Most Coleopterous larvae pupate without forming a cocoon, but a number cement pieces of wood or débris together, or form an earthen cell. The *pupa* (figs. R14, 15) is generally a true *pupa libera*, with pale, delicate cuticle and all parts of the imago free, though the wings are

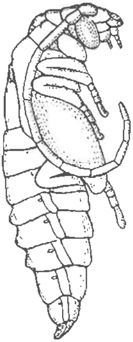


FIG. R14. Pupa of *Prionoplus reticularis* Wh., New Zealand, fam. Cerambycidae. Length 37 mm. [*R. J. T. del.*

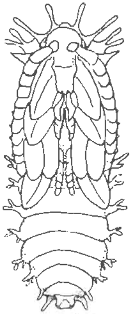


FIG. R15. Pupa of *Metriorrhynchus* sp., Australia, fam. Lampyridae. Ventral view. Length 12 mm. [*A. Tonnoir del.*

usually slightly glued together towards their tips. The Coccinellidae and some Chrysomelidae attach themselves by the tail, like many Butterfly pupae, which they somewhat resemble; these are forms evolving towards a pupa obtecta. Many of the Staphylinoidea posses a true *pupa obtecta*, with hard cuticle and parts soldered down, and the same type may also be found in some other groups. In many cases the pupa does not shed, or only partly frees itself from the old larval skin. The newly emerged imago frees itself without difficulty from the soft pupal skin, which shrivels up almost as completely as in the Mecoptera; the imago itself usually remains weakly chitinized for some time. These facts all indicate a rather primitive type of holometabolic development for this Order.

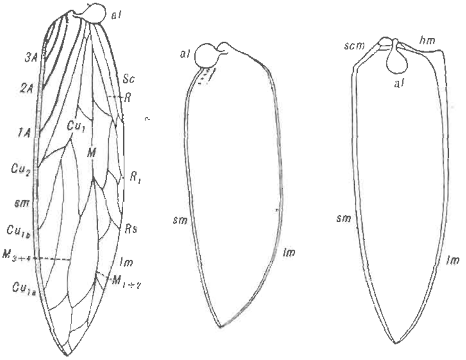
Inquilines. Australia being exceptionally rich in species of Ants and Termites, it is not surprising that a large number of species of other Orders have become associated with these insects, and that many forms live only in their nests. The Thysanuran genus *Atelura* (p. 50) has already been mentioned, and there are also a number of Hemiptera, particularly larval forms, which live with ants, though they have not yet been systematically worked out in Australia. Amongst the Coleoptera, however, there are a host of these so-called *inquilines*, living as guests or tenants in the nests of ants and termites, and a great deal of work has been done on them systematically, though little is yet known of their life-histories or of the nature of the bond between them and their hosts. These inquilines range from species which are only occasionally found associated with ants and termites up to highly specialized forms which evidently depend entirely upon their hosts for

their ability to exist. Some would appear to pass unnoticed or to be only tolerated, others are taken care of, probably for the sake of some secretion valued by the hosts, and others, again, are probably robbers or parasites, of whose injurious habits the hosts do not seem to be aware. Such inquilines occur in many families, but are most abundant in the Staphylinidae; other families which contain interesting and bizarre forms are the Cucujidae, Colydiidae, Pselaphidae, Scydmaenidae, Trichopterygidae, Histeridae and Ptinidae. Mr. A. M. Lea of the South Australian Museum has made a special study of Australian inquilines, and the selection of species figured in Plate 16 is due to him; the leading genera are mentioned under their respective families.

Distribution. The number of known Australian species is nearly 17,000, while the total for New Zealand is about 4,200. The most abundant families in Australia are the Curculionidae (3,246), Chrysomelidae (1,872), Scarabaeidae (1,869), Carabidae (1,565), Tenebrionidae (1,078), Cerambycidae (860), Buprestidae (766), Staphylinidae (617), Pselaphidae (468), Elateridae (364), Cleridae (299), and Coccinellidae (256). In New Zealand, the most abundant are the Curculionidae (1,274), Carabidae (479), Pselaphidae (361), Cerambycidae (240), Staphylinidae (204), Chrysomelidae (183), Tenebrionidae (152), Colydiidae (206), Elateridae (126) and Dascillidae (121). We see from this that the Weevils are by far the most abundant group in both faunas, while the Chrysomelidae, Carabidae, Tenebrionidae, Cerambycidae, Staphylinidae, Pselaphidae and Elateridae are also very well represented in both. In some of these families, however, Australia possesses peculiar tribes and even subfamilies not found at all in New Zealand, or even in any other part of the world. The Scarabaeidae, Buprestidae, Cleridae and Lampyridae, abundant in Australia, are all very poorly represented in New Zealand, the most striking case being the Buprestidae, with only two New Zealand species (an almost exact parallel with the natural order Proteaceae of plants). New Zealand, on the other hand, has more described Colydiidae and Dascillidae than Australia, and is comparatively rich in other families of obscure forms. In general, it may be said that the Australian fauna is characterized by an exceptional number of large, showy and beautiful forms, while the New Zealand fauna consists chiefly of small, obscure, dull-coloured species.

Economics. A large number of beetles are injurious to mankind through their attacks on his timber resources, his fruit and grain crops and his stored products; they are chiefly Bostrichidae, Lyctidae and Anobiidae (borers into dry wood), Dermestidae (pests of farm produce, museum specimens, etc.) a few Tenebrionidae (pests of meal and other dry produce), numerous Scarabaeidae and a few Lucanidae (attacking forest trees, fruit trees, cereals, sugar-cane and grass-crops), Cerambycidae, (borers into living timber), Chrysomelidae (leaf-feeders), Bruchidae (pea and bean-feeders), Scolytidae (tunnelers between bark and wood of trees), and a large number of Curculionidae (pests of all sorts of trees and plants, also of grain). A few groups are definitely beneficial, such as the Cicindelidae and Carabidae (ground scavengers, attacking many noxious insects) and Coccinellidae (predatory on scale insects and aphids). Details of the injurious and beneficial species, native and introduced, will be found under the headings of the respective families.

Fossil History. The oldest known fossil Coleopterous elytra come from the Upper Permian of Belmont and Newcastle, N.S.W., and consist of two families, the Permophilidae and Permosynidae. The former (fig. R17) are evidently the direct ancestors of the Hydrophilidae and, like them, possess a small *alula* (*al*) at the base of



16 17 18

FIG. R16 (left). Elytron of *Permofulgor* sp., Upper Permian of Belmont, N.S.W. (restored from two imperfect specimens): Order Protocoleoptera, fam. Permofulgoridae. Length 12 mm. *al*, alula (displaced to right); *lm*, lateral margin; *sm*, sutural margin; other lettering as in fig. A8, p. 22. Note that this elytron is quite flat. [*R. J. T. del.*

FIG. R17 (middle). Elytron of *Permophilus pincombei* Till., Upper Permian of Belmont, N.S.W. (restored from slightly damaged specimen). Order Coleoptera, fam. Permophilidae. Note that this elytron is slightly convex. Ventral view, with alula displaced to left. Lettering as in previous figure. Length 22 mm. [*R. J. T. del.*

FIG. R18 (right). Elytron of *Hydrophilus laticostatus* Cast., Recent, Australia; Order Coleoptera, fam. Hydrophilidae. Ventral view, with alula (*al*) in correct position; *hm*, humeral margin; *lm*, lateral margin; *scm*, scutellar margin; *sm*, sutural margin. Length 22 mm. [*R. J. T. del.*

the elytron. The Permosynidae contain small elytra of the genus *Permosyne*, with nine longitudinal striae, evidently ancestral to the Upper Triassic *Ademosyne* and allied genera found at Ipswich, Q. Alongside these Upper Permian Coleoptera there also occur the remains of an undoubted Protocoleopteron in the form of the large, flat elytron of *Protocoleus mitchelli* Till. (fig. ZA6), distinguished from a true Coleopterous elytron by having the sutural margin straight and a complete system of veins present, of a distinctly Protoblattoid type. This insect would appear to have been a specialized end-twig of the Order Protocoleoptera, and therefore not a direct ancestor of the true Coleoptera. However, in the same beds, there has recently been found a specimen of the genus *Permofulgor* (fig. R16), (originally placed by me in the Homoptera) having a complete, though narrow, sutural margin, and a distinct *alula* (*al*) of the Hydrophilid type attached to the base of the elytron. The Permofulgoridae are peculiar in that some of them have a complete but weak venation, while in others only the anal veins persist. They are best classed as Protocoleoptera of a

reduced type, lying very close to the ancestral line of the Permophilidae, and hence also of the Hydrophilidae.

The fossil evidence, so far as at present available, would tend to indicate that the original venation of the elytron was lost in the ancestors of the true Coleoptera, and that the development of longitudinal striae and intervals is an entirely new formation. If this be so, the almost smooth elytra of many Hydrophilidae probably represent the most primitive type, and the persistence of the alula and sometimes of weak tuberculation of the old anal area (indicating the last remnants of the more persistent anal veins) must also be regarded as archaic characters. It seems highly probable that the Adephaga, and perhaps also several of the main superfamilies among the Polyphaga, arose from separate groups within the Protocoleoptera, rather than from the ancestral stem of the Hydrophilidae. The Coleopterous fauna of the Upper Trias of Ipswich was very abundant, nearly half the known species from these beds belonging to this Order. Beetles are also abundant in Liassic and Upper Jurassic strata in Europe and in the various Tertiary beds of North America.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order COLEOPTERA 16,655 (4,425)

Suborder ADEPHAGA 1,921 (519)

I. CARABOIDEA 1,824 (513)
- 1. Carabidae 1,565 (479)
- 2. Cicindelidae 67 (16)
- 3. Hygrobiidae 2 (0)
- 4. Haliplidae 5 (0)
- 5. Dytiscidae 185 (18)

II. GYRINOIDEA 28 (1)
- 6. Gyrinidae 28 (1)

III. PAUSSOIDEA 58 (0)
- 7. Paussidae 58 (0)

IV. CUPOIDEA 3 (0)
- 8. Cupidae 3 (0)

V. RHYSODOIDEA 8 (5)
- 9. Rhysodidae 8 (5)

Suborder POLYPHAGA 14,734 (3,906)

VI. HYDROPHILOIDEA 115 (64)
- 10. Hydrophilidae 115 (64)

VII. CUCUJOIDEA 121 (23)
- 11. Cucujidae 121 (23)

VIII. COLYDIOIDEA 843 (430)
- 12 Colydiidae 123 (206)
- 13. Trogositidae 38 (23)
- 14. Cryptophagidae 8 (28)
- 15. Nitidulidae 119 (35)
- 16. Cisidae 13 (23)
- 17. Mycetophagidae 13 (10)
- 18. Erotylidae 73 (10)
- 19. Phalacridae 48 (0)
- 20. Georyssidae 2 (0)
- 21. Lyctidae 3 (0)
- 22. Bostrychidae 40 (2)
- 23. Heteroceridae 9 (0)
- 24. Lathridiidae 34 (54)
- 25. Endomychidae 28 (0)
- 26. Coccinellidae 256 (25)
- 27. Corylophidae 36 (14)

IX. BYRRHOIDEA 106 (61)
- 28 Dermestidae 60 (10)
- 29. Byrrhidae 46 (51)

X. HISTEROIDEA 122 (21)
- 30. Histeridae 122 (21)

XI. STAPHYLINOIDEA 1,229 (684)
- 31. Silphidae 38 (43)
- 32. Scaphidiidae 22 (19)
- 33. Scydmaenidae 77 (50)
- 34. Staphylinidae 617 (204)
- 35. Pselaphidae 468 (361)
- 36. Trichopterygidae 7 (7)

XII. LAMPYROIDEA 725 (82)
- 37. Lampyridae 201 (17)
- 38. Melyridae 216 (35)
- 39. Cleridae 299 (30)
- 40. Lymexylidae 9 (0)

XIII. DASCYLLOIDEA 213 (157)
- 41. Dascyllidae 34 (121)
- 42. Rhipidoceridae 13 (0)
- 43. Ptinidae 166 (36)

Suborder POLYPHAGA (*continued*)

XIV. ELATEROIDEA 1,218 (158)
- 44. Dryopidae 10 (10)
- 45. Buprestidae 766 (2)
- 46. *Throscidae* 2 (0)
- 47. Eucnemidae 75 (20)
- 48. Elateridae 364 (126)
- 49. Cebrionidae 1 (0)

XV. TENEBRIONOIDEA 1,920 (304)
- 50 Tenebrionidae 1,078 (152)
- 51 Cistelidae 162 (10)
- 52. Lagriidae 21 (1)
- 53. Melandryidae 60 (41)
- 54. Pythidae 24 (21)
- 55. Anthicidae 119 (20)
- 56. Pedilidae 102 (8)
- 57. Monommatidae 1 (0)
- 58. Rhipidophoridae 46 (4)
- 59. Mordellidae 127 (11)
- 60. Oedemeridae 101 (36)
- 61. Cantharidae 79 (0)

XVI. SCARABAEOIDEA 2,011 (124)
- 62. Passalidae 39 (0)
- 63. Lucanidae 68 (36)
- 64. Trogidae 35 (0)
- 65. Scarabaeidae 1,869 (88)

XVII. CERAMBYCOIDEA 2,746 (423)
- 66 Cerambycidae 860 (240)
- 67. Chrysomelidae 1,872 (183)
- 68. Bruchidae 14 (0)

XVIII. CURCULIONIODEA 3,365 (1,373)
- 69. Scolytidae 30 (8)
- 70. Platypodidae 11 (8)
- 71. Anthribidae 51 (81)
- 72. Brenthidae 27 (2)
- 73. Curculionidae 3,246 (1,274)

XIX. AGLYCYDEROIDEA 0 (2)
- 74. Aglycyderidae 0 (2)

In the above census, the totals for Australian Caraboidea were supplied by Mr. T. Sloane, those for Australian Buprestidae, Elateridae, Tenebrionidae, Cistelidae and Chrysomelidae by Mr. H. J. Carter, and those for the remainder of the Australian species by Mr. A. M. Lea. The New Zealand figures were provided by Mr. A. E. Brookes, and include 112 species peculiar to the Chatham, Kermadec and Subantarctic Islands.

The classification of the immense mass of forms found within the Order is a matter of great difficulty, and can only be said to be partially accomplished with satisfaction. The original type (archetype) of the Order was almost certainly a somewhat elongate form with the elytra covering the abdomen, with little or no infolding of the apical portion of the hindwing, with complete mouth-parts but probably only a simple maxillary galea, and with freely movable abdominal segments; it must also have possessed a primitive caraboid larva. At the present time, no representative of this original group exists, though the Cupidae stand fairly close to it, and serve to link the two recognized Suborders together; this family has, however, a somewhat specialized, wood-boring larva. Students of the internal anatomy of the Order have shown that they can recognize two main divisions on the characters of the ovaries and testes; on the one hand, the Adephaga have polytrophic ovaries and simple, tubular testes; on the other, the Polyphaga have telotrophic ovaries and acinose testes. Though the simple, tubular type of testis may be primitive, both types of ovary are specialized, and neither can be derived from the other, but only from an original panoïstic type. Comparing these results with those of the external morphology, we find again that the Adephaga have the more primitive and complete venation, but specialized in the formation of the oblongum, while the Polyphaga have the venation specialized in another direction. The Adephaga have mostly primitive, filiform antennae, while the Polyphaga have the most primitive form of hind coxal cavities, since these completely divide the first ventral segment in the Adephaga. We can thus state definitely that the original type has been lost, and that the Order is represented to-day by two phylogenetically equal, though numerically very unequal, Suborders, defined below.

In dividing the Suborders into superfamilies and families, use is made of the following characters:—

1. *Form of the antennae*:—The main types are defined on p. 14 and illustrated in fig. A4.
2. *Number and form of the tarsal segments*:—The primitive number is five to each tarsus; this is conveniently indicated by the formula "tarsi 5-5-5", the figures indicating the number of segments in the fore, middle and hind tarsus respectively. If the hind tarsus has only four segments, as in Tenebrionoidea or Heteromera, the formula is "tarsi 5-5-4". Some families have the formula 4-4-4 or even 3-3-3. Care must be taken by the student over those cases in which one segment is reduced to a small nodule (see fig. R65).
3. *Shape and position of the coxal cavities or acetabula*:—The primitive condition of an acetabulum is a round or oval socket with a complete rim, enclosed by its corresponding pleuron and sternum. This socket may become specialized by extension, either transversely or longitudinally, and may open backwards between pleuron and sternum; in the case of the hind coxae, the cavities pass backwards into the basal visible abdominal sternite, and, in all the Adephaga except Cupidae, entirely divide it longitudinally. Also, any given pair of coxal cavities may be well separated (the primitive condition), closely approximated, or contiguous.
4. *Number and condition of abdominal segments*:—This has already been discussed on pp. 180-182. In classification, we shall indicate the number of *visible sternites* and also state whether, in addition, portions of an extra basal tergite can be seen latero-ventrally.
5. *Form of the prosternum*:—A specialized condition of this sclerite is sometimes used in classification, as in the case of the Elateroidea (p. 215).
6. *Softness or hardness of the chitinization* of the cuticle and elytra, *abbreviation* of the elytra and exposure of pygidium.
7. *Presence or absence of the gular plate*:—Two longitudinal sutures, placed close together near the middle of the ventral surface of the head, separate the *gular plate* (fig. R2, *gp*) from the large latero-ventral extensions of the genae (*ge*); these sutures sometimes coalesce in the middle. In the Curculionoidea they coalesce entirely, so that the gular plate is absent.

The Order is divisible into two Suborders, which can be distinguished as follows:—

Abdomen with basal visible sternite completely divided longitudinally by hind coxal cavities (except in Cupidae); hindwing with one or two cross-veins near middle and with a closed cell, the oblongum,* developed on *M*; antennae mostly filiform (except in Gyrinidae and Paussidae). Suborder ADEPHAGA

Abdomen with basal visible sternite not completely divided longitudinally by hind coxal cavities; hindwing without cross-

*Secondarily incomplete in Rhysodidae and some Cicindelidae.

veins and oblongum, either with a subtriangular cell between *M* and Cu_1, open basally (the apertum), or else of a reduced type derived from this; antennae very variable in form.
Suborder POLYPHAGA

Suborder ADEPHAGA

In this Suborder we include not only those families usually classed as Caraboidea, but also the Gyrinidae, Paussidae, Cupidae and Rhysodidae, each of which is placed in a separate superfamily. All of them have tarsi 5-5-5. The Gyrinidae are a highly specialized offshoot of the aquatic Caraboidea, as their larvae clearly prove. The Paussidae differ from true terrestrial Caraboidea only in their highly specialized antennae, reduced galeae and lesser number of visible sternites. The Cupidae stand far apart from the rest of the Suborder and are certainly one of the most archaic of existing families of beetles; as they combine characters belonging to both Suborders, they might be placed in one or the other with almost equal reason. The primitive but completely Adephagous character of the hindwing venation should, in our opinion, decide the question, although the larval characters of the family are Polyphagous. The Rhysodidae have both venation and hind coxal cavities of Adephagous type. Both Cupidae and Rhysodidae may be considered as to some extent annectent with the Polyphaga, in which their closest relatives appear to be the Cucujoidea.

The larvae of this Suborder are mostly of an active, predatory type, with large or medium head, powerful jaws, well developed legs and tarsi usually ending in a pair of claws; the abdomen has from seven to nine distinct segments, the last carrying either a pair of processes, a terminal tube or sucker (reduced tenth segment), or both.

The following Key will distinguish the superfamilies:—

1. First visible sternite of abdomen completely divided longitudinally by hind coxal cavities. 2
   First visible sternite not completely divided longitudinally by hind coxal cavities; number of visible sternites 5. IV. CUPOIDEA
2. Aquatic beetles with very short antennae; each eye divided into two distinct parts; middle and hind legs paddle-shaped; number of visible sternites 6, with an additional basal tergite visible latero-ventrally. II. GYRINOIDEA
   Not as above. 3
3. Head divided posteriorly by two longitudinal grooves into a median ridge and two ocular lobes; antennae moniliform or filiform; mentum large, covering the mouth-parts; pronotum, elytra and abdominal sternites with longitudinal grooves; hind coxal cavities wide apart. V. RHYSODOIDEA
   Not such beetles; hind coxal cavities contiguous or nearly so. 4
4. Antennae 11-segmented, more or less filiform, with normal pedicel; maxillae with galea almost always with two segments. I. CARABOIDEA
   Antennae apparently only 10-segmented, but actually 11-segmented with minute, nodular pedicel hidden in the bulbous scape; the nine distalia forming a broad, flattened lamina, rounded apically. III. PAUSSOIDEA

Superfamily I. CARABOIDEA

This group contains five families, two of which are terrestrial and three aquatic; they have six visible sternites, of which the basal one is only present latero-ventrally. They are distinguished as follows:—

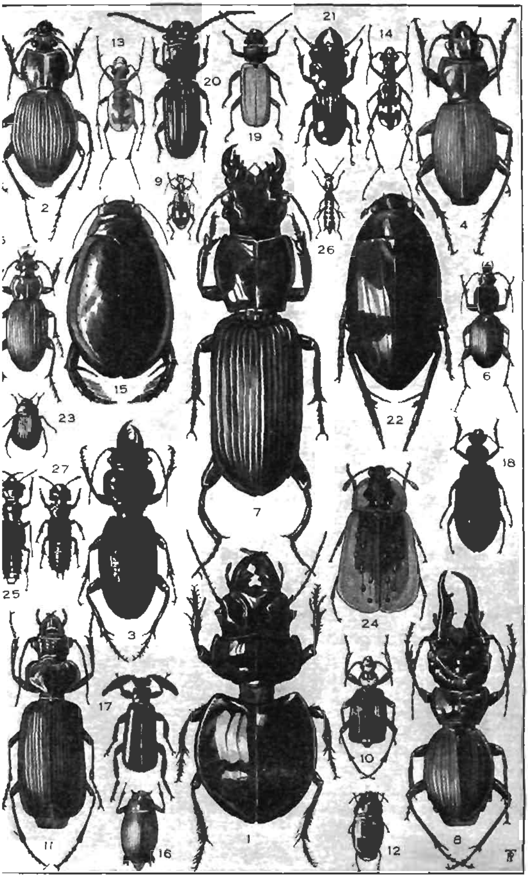
1. Terrestrial beetles with all three pairs of legs adapted for running or, rarely, forelegs formed for burrowing; hind coxae either not touching, or only touching at a point. 2
   Aquatic beetles with one or more pairs of legs more or less completely adapted for swimming; hind coxae in contact for a considerable distance. 3
2. Head held horizontally, usually narrower than thorax; clypeus not extending laterally in front of insertions of antennae. Fam. 1. CARABIDAE
   Head held vertically, wider than thorax; clypeus extending laterally below insertions of antennae. Fam. 2. CICINDELIDAE

Plate 17

COLEOPTERA (Adephaga to Staphylinoidea)

All figures natural size, except figs. 9 and 26

1. *Euryscaphus waterhousei* Macl. (Fam. Carabidae).
2. *Pamborus opacus* Géhin. (Fam. Carabidae).
3. *Mecodema o'connori* Broun (Fam. Carabidae), N.Z.
4. *Ceratoferonia phylarchus* Sl. (Fam. Carabidae).
5. *Pterostichus opulentus* Broun (Fam. Carabidae), N.Z.
6. *Notonomus arthuri* Sl. (Fam. Carabidae).
7. *Hyperion schroetteri* Schr. (Fam. Carabidae).
8. *Mecynognathus dameli* Macl. (Fam. Carabidae), male.
9. *Demetrida nasuta* Wh. (Fam. Carabidae), N.Z. (x 1.3).
10. *Pheropsophus verticalis* Dejean (Fam. Carabidae).
11. *Gigadema maxillaris* Sl. (Fam. Carabidae).
12. *Silphomorpha albopicta* Newm. (Fam. Carabidae).
13. *Cicindela latecincta* Wh. (Fam. Cicindelidae), N.Z.
14. *Distypsidera undulata* Wwd. (Fam. Cicindelidae).
15. *Cybister gayndahensis* Macl. (Fam. Dytiscidae), female.
16. *Macrogyrus latior* Clark (Fam. Gyrinidae).
17. *Arthropterus wilsoni* Wwd. (Fam. Paussidae).
18. *Omma stanleyi* Newm. (Fam. Cupidae).
19. *Ipsaphes bicolor* Oll. (Fam. Cucujidae).
20. *Hectarthrum brevifossum* Newm. (Fam. Cucujidae).
21. *Parandra frenchi* Blkb. (Fam. Cucujidae), male.
22. *Hydrophilus latipalpus* Cast. (Fam. Hydrophilidae).
23. *Rygmodus modestus* Wh. (Fam. Hydrophilidae), N.Z.
24. *Ptomaphila lachrymosa* Schr. (Fam. Silphidae).
25. *Actinus macleayi* Oll. (Fam. Staphylinidae).
26. *Paederus sparsus* Fvl. (Fam. Staphylinidae), (x 1.3).
27. *Staphylinus huttoni* Broun (Fam. Staphylinidae), N.Z.



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COLEOPTERA (ADEPHAGA TO STAPHYLINOIDEA)

3. Metasternum with a distinct antecoxal piece separated by a well-marked suture. 4
Metasternum without a distinct antecoxal piece; hind tibiae very short, hind tarsi strongly modified for swimming. Fam. 5. DYTISCIDAE

4. Hind coxae narrow, not covering femora; antecoxal piece of metasternum truncate behind. Fam. 3. HYGROBIIDAE
Hind coxae broad, forming large plates covering the three basal segments of the abdomen and two-thirds of the hind femora; antecoxal piece of metasternum projecting triangularly backwards in the middle. Fam. 4. HALIPLIDAE

Family 1. **Carabidae** (Ground Beetles, Carabs) [Aus. 1565, N.Z. 479]. All three pairs of legs similar, or forelegs specialized for burrowing; antennae filiform or somewhat moniliform, partially pubescent; clypeus not extending beneath base of antennae; maxillae with galea almost always two-segmented, lacinia usually with terminal hook, never articulated. Larvae terrestrial or arboreal, active and predatory.

An enormous family, strongly represented in both countries. The Australian fauna is remarkable in having a number of groups either peculiar to it or but little represented elsewhere. Of the very large number of subfamilies only the more outstanding can be mentioned here.

The Scaritinae are an interesting group of burrowing forms, having the forelegs specialized for that purpose. They are well represented in Australia, but only a single species, *Clivina rugithorax* Putz., is found in New Zealand. They are very hard beetles, strongly constricted between prothorax and afterbody, and often of beautiful metallic colours. The principal Australian genera are *Carenum, Carenidium, Scaraphites, Laccopterum, Philoscaphus* and *Euryscaphus*. *Carenidium spaldingi* Macl. (pl. 15, fig. 2) is one of the handsomest species, while *Euryscaphus waterhousei* Macl. (pl. 17, fig. 1), from Central Australia, is the giant of the group.

The widespread Carabinae are absent from New Zealand and only represented in Australia by the genera *Calosoma* and *Pamborus*, the latter confined to Eastern Australia. The beautiful green *Calosoma schayeri* Er. is common in rich alluvial lands in Eastern Australia and is a valuable ally of the farmer. The species of *Pamborus* are of handsome shape, with small head, large prothorax strongly constricted behind, and often having metallic greenish or coppery tints, especially along the edges of the elytra; they discharge an offensive fluid when handled. Two of the best known species are *P. alternans* Latr. and *P. opacus* Géhin (pl. 17, fig. 2).

The Broscinae are a widespread group, more strongly represented in Australia and New Zealand than elsewhere. The Australian genus *Gnathoxys* contains curiously sculptured black species. *Mecodema o'connori* Broun (pl. 17, fig. 3) found on Stephens Island, is the finest of the New Zealand species.

The great group Pterostichinae contains a large number of handsome species, many of them being of large size. *Pterostichus* and *Trichosternus* occur in both countries. Well-known species in New Zealand are *Pt. meritus* Broun, dark metallic green, and *Pt. opulentus* Broun (pl. 17, fig. 5), about the same size, black with coppery red pronotum; *T. crassalis* Broun and *T. antarcticus* Chaud. are larger, handsome, dark metallic green species. In Australia *Trichosternus imperialis* Sl., *T. renardi* Chaud., *Ceratoferonia phylarchus* Sl. (pl. 17, fig. 4), *Mecynognathus dameli* Macl. (pl. 17, fig. 8) and *Catadromus lacordairei* Bd. (fig. R1) are all fine species; the last-named is black, edged with green, and is quite common. *Notolestus sulcipennis* Macl. (pl. 15, fig. 3) is a rare species of exceptionally beautiful form and sculpture, found at altitudes from 2,000-5,000 ft. in northern N.S.W. The largest of the Australian species are the huge *Catadromus elseyi* Wh. and *Hyperion schroetteri* Schr. (pl. 17, fig. 7), both measuring over 2 inches in length. The genus *Notonomus* is abundant throughout Australia; it contains mostly medium-sized species of which *N. arthuri* Sl. (pl. 17, fig. 6) is a good example. The allied Helluoninae, absent from New Zealand, also contains a large number of species in Australia, most of them being of medium or small size; the brown *Helluo costatus* Bon., about an inch long, is very common. *Gigadema maxillaris* Sl. (pl. 17, fig. 11) is one of the most striking Australian species. The Bembidiinae include a large number of riparian species in both countries; most of these are quite small.

The Merizodinae are an Antarctic group, best represented in New Zealand and Tasmania. They are small species with oval elytra. The so-called species of

Oopterus in New Zealand do not belong to that genus, but require a new name. The Pentagonicinae are represented by a number of species of *Pentagonica* and *Scopodes*, small, swamp-haunting beetles found in Australia, New Zealand and New Caledonia. The Brachyninae are poorly represented in Australia and absent from New Zealand; the best known species is the common Australian "Bombadier Beetle," *Pheropsophus verticalis* Dejean (pl. 17, fig. 10), found under stones; it is black, with orange-red spots on the elytra, and, when disturbed, discharges a cloud of vapour with a distinct report.

The dominant group Lebiinae is well represented in both countries by small, very active, shiny brown or black beetles of normal Carabid shape, often with black or reddish markings; they are very abundant under loose bark. *Demetrida nasuta* Wh. (pl. 17, fig. 9) is a well-known New Zealand species, dark brown, with pale marks on elytra. A more specialized bark-haunting group, absent from New Zealand, but more abundant in Australia than anywhere else, is the Pseudomorphinae; these beetles have lost the normal Carabid shape and have become oval in outline. They are mostly blackish with orange-brown markings, and run with great rapidity. *Silphomorpha albopicta* Newm. (pl. 17, fig. 12) is typical of the group; *S. grandis* Cast. and *S. speciosa* Pasc. are larger species, the former black, the latter brightly coloured. The allied genus *Adelotopus* contains smaller bark-haunting species associated with ants, such as *A. castaneus* Cast. (pl. 16, fig. 2). Both genera are believed to prey upon ants.

One of the most peculiar genera of Australian Carabidae is *Illaphanus* (subfam. Bembidiinae), which contains the minute species *I. stephensi* Macl. (pl. 16, fig. 1) and *I. macleayi* Lea, pale testaceous beetles which are quite blind and live under stones in New South Wales and Tasmania, in association with ants.

Family 2. **Cicindelidae** (Tiger Beetles) [Aus. 67, N.Z. 16]. Head deflexed, held more or less vertically, and wider than prothorax; clypeus extending laterally beneath bases of antennae; lacinia usually with an articulated terminal hook, maxillary palp inserted on a prominence which frequently resembles another segment.

The tiger beetles are very active, swift runners and mostly also capable of rapid flight. They frequent open, sandy, heathy or clayey country, or haunt the trunks of forest trees. The larvae make cylindrical burrows in soil; those of *Cicindela* are known in New Zealand as "penny doctors"; they have a large head and cylindrical body, and prey on other insects, which they seize with their strong mandibles. All the New Zealand and nearly half the Australian species belong to the world-wide genus *Cicindela*. *C. ypsilon* Dejean occurs on sandy beaches in South and Eastern Australia; the best known of the New Zealand species are *C. parryi* Wh., about 10 mm. long, and the somewhat larger and handsomer *C. tuberculata* Fabr. and *C. latecincta* Wh. (pl. 17, fig. 13); they are dark olive in colour with straw-coloured markings on the elytra. The species of *Distypsidera* frequent tree-trunks in the warmer parts of Eastern Australia; *D. undulata* Wwd. (pl. 17, fig. 14) is one of the best known species. *Nickerlea* is a Western Australian genus intermediate between this and *Cicindela*. The finest and most showy species are the tropical representatives of the genus *Megacephala*; *M. australis* Chaud. (pl. 15, fig. 1) is metallic green with face, legs and tips of elytra yellowish; *M. crucigera* Macl. has yellowish elytra with a cross-shaped mark of metallic green on them. *Tricondyla aptera* Ol. is a large, black, wingless species about an inch long, resembling a huge ant; it occurs in North Queensland and Papua.

Family 3. **Hygrobiidae (Pelobiidae)** [Aus. 2, N.Z. 0]. These are Caraboid forms slightly modified for an aquatic existence. Antennae bare; maxilla with two-segmented galea; metasternum with antecoxal piece present, truncate behind; hind coxae normal; hind legs formed for swimming, with tarsi longer than tibiae. The only genus is *Hygrobia* Latr. 1804 (= *Pelobius* Schh. 1808).

Family 4. **Haliplidae** [Aus. 5, N.Z. 0]. Aquatic beetles with bare antennae, 11-segmented*; metasternum with antecoxal piece present, projecting triangularly backwards; hind coxae in the form of large plates covering the basal parts of the abdomen and hind femora. Larvae with mandibles grooved for sucking. *Haliplus* is the only genus represented in Australia; the species are all small.

Family 5: **Dytiscidae** (Water Beetles) [Aus. 185, N.Z. 18]. Smooth,

*Most text-books state that the antennae in this family are 10-segmented, but this is an error as a careful preparation in 10 per cent. KOH will easily show.

shining, oval, aquatic beetles with bare, filiform, 11-segmented antennae; galea two-segmented; metasternum without an antecoxal piece, but closely united posteriorly with the enormous hind coxae; hind tibiae very short; hind tarsi strongly modified for swimming. Larvae (fig. R7) elongate, active, predatory, with mandibles perforated for sucking the prey; abdomen with only 8 segments, the last one narrow and much elongated, tube-like.

This family contains species varying in size from very small to over an inch in length, nearly all dull in colour. Both larva and imago breathe by rising to the surface of the water and taking in air, the larva through the end pair of spiracles (the only ones present) and the imago by filling with air the space enclosed between abdomen and elytra. The hind tarsi are highly modified by flattening of the segments and development of a strong brush of hairs, thus forming a very efficient pair of paddles for swimming. *Eretes australis* Er. (fig. R19) is the commonest Australian species, dull medium brown in colour; this *beetle swarms in all the waterholes of the interior, and is an important article* of diet for many aquatic birds. The great genus *Cybister* is represented by a number of fine species in Australia, of which *C. gayndahensis* Macl. (pl. 17, fig. 15), brown with orange margins to elytra, is one of the best known. The males in these two genera have the first three segments of the fore tarsi greatly enlarged to form a kind of sucker (fig. R19) used for clinging to the female when pairing. The genus *Sandracottus* contains two Australian species about 12 mm. long with striking colour-pattern; the somewhat smaller *Macroporus howitti* Clark is dark red with black markings. The New Zealand species are placed in six genera; one of the commonest species is *Rhantus pulverulosus* Steph., dull brown, 12 mm. long.

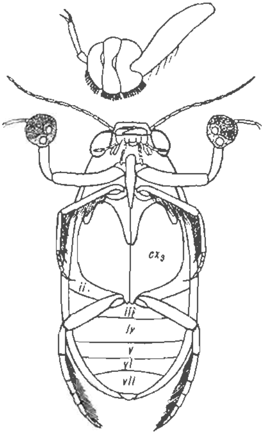

FIG. R19. *Eretes australis* Er., Australia, fam. Dytiscidae. Ventral view of male. Length 14 mm. Lettering as in fig. R1. Above, dorsal view of fore tibia and tarsus, showing segmented condition of sucker (x 11). [*R. J. T. del.*

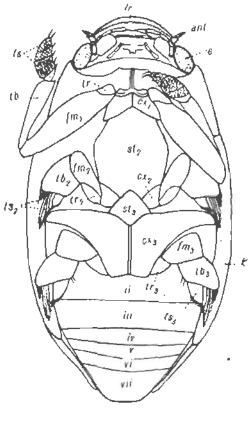

FIG. R20. *Macrogyrus striolatus* Guer., Australia, fam. Gyrinidae. Ventral view. Length 16 mm. Lettering as in fig. R1, except *e*, ventral portion of divided eye; *k*, lateral keel; *lr*, labrum. [*R. J. T. del.*

Superfamily II. GYRINOIDEA.

Family 6. **Gyrinidae** (Whirligig Beetles) [Aus. 28, N.Z. 1]. Smooth, oval, aquatic beetles with very short antennae; eyes widely divided into separate

dorsal and ventral parts, the former for aërial and the latter for subaqueous vision; a lateral keel-line surrounds the body at water-level and passes between the two parts of each eye; fore legs strongly built, middle and hind legs modified into short paddles.

These beetles are well known for their performance of complicated whirling evolutions on the surface of fresh water, whence their popular name of "whirligig beetles". Their long, slender eggs are laid on water-weed; their active, predatory and exceedingly voracious larvae (fig. R8) are elongated, with small head, biting mandibles, tarsi ending in two claws, abdomen with ten segments, the first eight each having a single pair and the ninth two pairs of lateral gills. In Australia the genus *Macrogyrus* contains a number of species up to half-an-inch or more in length, of which *M. striolatus* Guer. (fig. R20) and *M. latior* Clark (pl. 17, fig. 16) are good examples: they are all dull coloured, mostly blackish insects. *Gyrinus huttoni* Pasc. is the only New Zealand species.

Superfamily III. PAUSSOIDEA.

Family 7. **Paussidae** [Aus. 58, N.Z. 0]. These curious beetles can be at once recognized by their extraordinary antennae (fig. R21, A) which are in most cases apparently only 10-segmented but actually possess 11 complete segments,

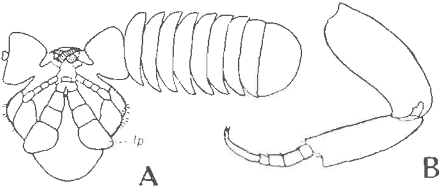

FIG. R21. *Arthropterus westwoodi* Macl., Australia, fam. Paussidae. A, ventral view of head, with flagellum of right antenna removed to show nodular pedicel; note the small crossed mandibles and large labial palpi (*lp*). (10 per cent KOH preparation, × 12). B, fore leg (× 12). [*R. J. T. del.*

the small nodular pedicel being hidden in the head of the large swollen scape; the flagellum has the segments co-adapted so as to form a broad, flattened *lamina**; hind coxal cavities and wing-venation of true Adephagous form; abdomen with only four visible sternites; pygidium and sometimes propygidium exposed; legs (fig. R21, B) broad and flat; tips of the elytra usually membranous. Most of the Australian species belong to the genus *Arthropterus*, rare beetles found under bark and logs, or in ants' nests; they are very sluggish, but are capable of bombarding and are sometimes taken at light. The best known species is the dull brown *A. brevis* Wwd.; *A. wilsoni* Wwd. (pl. 17, fig. 17) is one of the finest. *Megalopaussus amplipennis* Lea, from Queensland, is the largest species and has the pedicel of the antenna free and visible without special preparation. Nothing is known of the life-histories of Australian species.

Superfamily IV. CUPOIDEA

Family 8. **Cupidae** [Aus. 3, N.Z. 0]. This family is placed in the Adephaga on its wing-venation (fig. R4), which is the most primitive type still existing, with a well defined oblongum; but actually it is an annectent group between the Adephaga and Polyphaga, as the hind coxae do not completely divide the first visible sternite (fig. R22) and the larvae are cylindrical wood-borers with only a single tarsal claw. Antennae filiform or somewhat moniliform; number of visible sternites 5. All three species are very rare, the best known being *Omma stanleyi* Newm. (pl. 17, fig. 18), a dull brownish or blackish insect of handsome shape and sculpture, about 15 mm. long, having a complex clathrate pattern on

*In some non-Australian genera this lamina is a single whole, with segmental divisions obliterated.

the clytra. *O. mastersi* Macl. is a handsomer species with whitish hairs on head and parts of the clytra. *Cupes varians* Lea is the only other species.

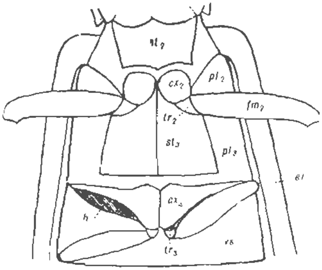

FIG. R22. *Omma stanleyi* Newm., Australia, fam. Cupidae. Ventral view of pterothorax and first visible sternite, with tibiae and tarsi omitted. *cx*, coxa; *el*, elytron; *fm*, femur; *h*, concavity at base of abdomen for reception of femur; pl_2, mesopleuron; pl_3, metapleuron: st_2, mesosternum; st_3, metasternum; *tr*, trochanter; *vs*, basal visible abdominal sternite (× 10). [*R. J. T. del.*

Superfamily V. RHYSODOIDEA

The single family contained in this group shows some affinity with the Cupidae on the one hand and the Cucujidae on the other, but is so distinctly characterized that it seems best to place it in a separate superfamily. Hind coxal cavities wide apart, dividing the first visible abdominal sternite into three separate pieces, viz. a broad median one and two narrow lateral ones. The tarsal formula is given in some text-books as 4-4-4, but all specimens which we have examined from Australia and New Zealand have five-segmented tarsi (fig. R23).

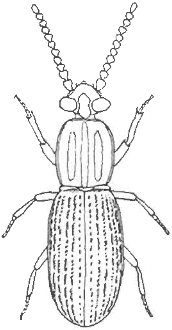

FIG. R23. *Rhysodes orbitosus* Broun, New Zealand, fam. Rhysodidae. Length 4.5 mm. [*A Tonnoir del.*

Family 9. **Rhysodidae** [Aus. 8. N.Z. 5]. All the species belong to the genus *Rhysodes* and are blackish in colour, with strong sculpturing of pronotum and elytra; they measure from 4 to 8 mm. in length. Two of the best known species are *Rh. abbreviatus* Lea from Queensland and *Rh. orbitosus* Broun (fig. R23) from New Zealand. *Life-history unknown.*

Suborder POLYPHAGA

THIS Suborder includes an immense number of diverse forms which agree in lacking the oblongum in the hindwing, in having the hind coxal cavities not completely dividing the first visible abdominal sternite longitudinally, and in the larval tarsi never ending in two claws. The classification of the Suborder into superfamilies and families is a task of the greatest difficulty. Though certain large groups are well defined and easily recognized, there remains over, after these have been taken out, a great number of obscure forms whose affinities are not yet fully understood; these for the most part are to be found in the old groups called Clavicornia and Serricornia. These two groups are admittedly unnatural, and could neither be logically defined nor left as distinct superfamilies in this book; an attempt has therefore been made to separate out from them a

number of smaller groups which appear to be sufficiently distinct to deserve superfamily rank. Even so, the residium, here defined as Colydioidea, probably contains more than one group deserving of superfamily rank; but much more research work must be done on the more obscure families before a satisfactory division will be possible. No less than fourteen superfamilies are recognized. For the sake of conformity with the scheme adopted for all other Orders in this book, these are given names ending in *-oidea* and derived from the principal family in each case; but, as many of these superfamilies are the same as the "series" used by Coleopterists, the older serial names are given in brackets, and these names can, of course, be used in preference to the others, if so desired. The following Key will distinguish the Superfamilies:—

1. Antennae lamellate*; larvae with soft, curved body and well developed legs (*melolonthoid type*). XVI. SCARABAEOIDEA.
   Antennae not lamellate; larvae not as above (if with soft, curved body, then legs small or absent). 2
2. Tarsi 5-5-4 in both sexes. XV. TENEBRIONOIDEA
   Tarsi not as above.† 3
3. Tarsi apparently 3-3-3, the second segment lobed. XIX. AGLYCYDEROIDEA
   Tarsi not as above. 4
4. Tarsi apparently 4-4-4,‡ with segs. 1-3 pubescent beneath, the third segment lobed (or, if not lobed, then the whole tarsus is excessively slender and folded back at an angle to the tibia§). 5
   Tarsi not as above. 6
5. Head usually more or less prolonged into a snout or rostrum; gular plate absent; palpi usually rigid; hard, strongly chitinized forms with tough elytra. XVIII. CURCULIONOIDEA
   Head not usually prolonged into a snout or rostrum; gular plate *present*; *palpi flexible*. XVII. CERAMBYCOIDEA
6. Antennae very short, often shorter than the long maxillary palpi, with 6-10 segments and ending in a pubescent club; tarsi 5-5-5; elytra completely covering abdomen. VI. HYDROPHILOIDEA
   Antennae not as above (if shorter than maxillary palpi, then elytra not covering abdomen**). 7
7. Prosternum with a backward process which fits into a cavity of the mesosternum; antennae not clubbed (except in *Throscus* and a few *Dryopidae*). XIV. ELATEROIDEA
   Prosternum not as above. 8
8. Hard, compact beetles, strongly armoured; antennae 11-segmented, short, bent, capitate, with scape well developed; elytra truncate behind, leaving pygidium and propygidium exposed. X. HISTEROIDEA
   Not such beetles. 9
9. Labium with broad, transverse submentum, in front of which is a membranous area giving origin to the prominent palpi and, behind these, to the bilobed ligula; hindwing with returning vein absent or, vestigial, *M* ending on the wing-margin; elytra hard, often greatly shortened. XI. STAPHYLINOIDEA
   Beetles not having the above combination of characters. 10
10. Elongate beetles with soft cuticle and elytra (these latter sometimes shortened); tarsi always 5-5-5. XII. LAMPYROIDEA
    Not as above. 11
11. Hind coxae formed to receive the femur when retracted; tarsi 5-5-5, but very short. IX. BYRRHOIDEA
    Not as above. 12
12. Elongate beetles either greatly flattened or thick and cylindrical; elytra usually more or less parallel-sided; antennae variable, never actually clubbed, though the terminal segments are sometimes stouter than the

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*Except in a few Lucanidae, which are easily recognized apart from this character.

†Tarsi 5-5-4 *in males only* of some Cucujoidea and Cryptophagidae.

‡By suppression of the true fourth segment, which can still be made out, in KOH preparations of some forms, as a tiny nodule enclosed by the lobed third segment. See also fig. R65.

§This exception applies only to the Platypodidae, which tunnel in wood and keep their tarsi folded back against the tibiae.

**Antennae shorter than maxillary palpi in a few Pselaphidae only.

rest; tarsi 5-5-5, sometimes 5-5-4 in males only; abdomen with five visible sternites, all movable. VII. CUCUJOIDEA

Beetles not having the above combination of characters. 13

13. Antennae of short to medium length, with 10-11 segments and ending in a more or less well-marked club, formed usually of three segments (seven in Heteroceridae, two in Lyctidae). VIII. COLYDIOIDEA

Antennae usually much longer than above, filiform, serrate or flabellate (rarely shortened in a few inquiline Ptinidae, in which the antennae may be flattened into a lamina, strongly moniliform, or strongly capitate with only six segments). XIII. DASCYLLOIDEA

Superfamily VI. HYDROPHILOIDEA (PALPICORNIA).

This very ancient and isolated group can be traced back geologically to the Upper Permian (see p. 186) and is perhaps the oldest of existing Coleopterous groups. In addition to the characters given in the Key, we may note the presence of the *alula* (fig. R18, *al*) attached ventrally to the base of the elytron, the presence of a well-developed *apertum* and *returning vein* in the hindwing, together with a strong cross-vein below Cu_1 before the middle; the large submentum, which conceals the rest of the labium; the long maxillary palpi, often longer than antennae; the elongated hind coxae, reaching completely across the body; and the presence of *five visible sternites*. *Larva active, predatory*, caraboid, aquatic or terrestrial, with strong biting mandibles; tarsi short, claw-like or absent.

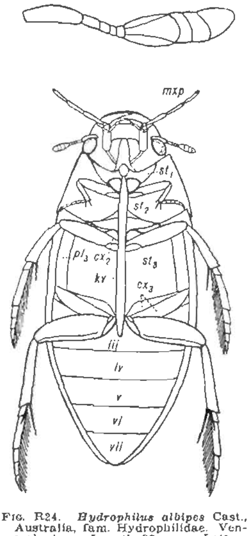


FIG. R24. *Hydrophilus albipes* Cast., Australia, fam. Hydrophilidae. Ventral view. Length 37 mm. Lettering as in fig. C1; except *kv*, mid-ventral keel; *mxp*, maxillary palp. Above, antenna (× 11). [*R. J. T. del.*

Family 10. **Hydrophilidae** [Aus. 115, N.Z. 64]. This family contains for the most part aquatic or semi-aquatic species of dull coloration and smooth, oval form, superficially resembling Dytiscidae, but much more convex dorsally; the middle and hind legs are usually more or less modified to serve as paddles. Some of the genera, e.g., *Hydrophilus*, have a strongly projecting, mid-ventral keel between the three pairs of coxal cavities and ending in a sharp process below the base of the abdomen. The shining black *Hydrophilus latipalpus* Cast. (pl 17, fig. 22) and *H. albipes* Cast. (fig. R24) are two of the largest Australian species; the commonest Australian species are *Sternolophus nitidulus* Macl. and various species of *Cyclonotum*. *Pseudohydrobius* contains two Australian species found on flowers. The best known New Zealand species are the steely blue *Rygmodus modestus* Wh. (pl. 17, fig. 23), the purple *R. puncticeps* Broun and the dull blackish *Hydrobius zealandicus* Broun, all about 6 mm. long. The small species of *Berosus* occur in both countries. The genus *Cyloma* is terrestrial and has four species in New Zealand.

Superfamily VII. CUCUJOIDEA.

This is a somewhat archaic group showing affinities with Cupidae on the one hand and Colydiidae on the other. Though fairly easy to recognize in practice, the group is most difficult to define, as it contains a number of aberrant forms which are not easy to fit into a Key. For the present we think it best to recognize only a single family Cucujidae, but with fuller knowledge there can be little doubt that a division into five or six fairly well-marked families will be advis-

and hence various Cucujid genera show close affinities with archaic genera in other families. In order to enable the student to grasp the family characters more easily, we have illustrated a number of leading types both in the text and plates.

The condition of the tarsi in this family is of considerable interest, as in many cases the males show the arrangement 5-5-4 typical of the Tenebrionoidea or Heteromera (both sexes); the four-segmented condition of the hind tarsi is attained by loss of the short fourth segment. The genus *Parandra* has the first segment longer than the second or third, and each of them with a ventral pad, thus showing an approach to the Cerambycid type; but the third segment is not bilobed, and the true fourth segment is present as a small but quite distinct nodule visible to the naked eye (fig. R25,D). The antennae of Cucujoidea are very variable in form and length, but are never truly clubbed as in the Colydioidea; the nearest approach is in the subfamily Silvaninae. The hindwing is of primitive Polyphagous type, with well-marked returning vein and apertum. The larvae are elongate, cylindrical or strongly flattened, with short legs; the abdomen ends in a hard plate, which in many cases is very curiously sculptured (fig. R9).

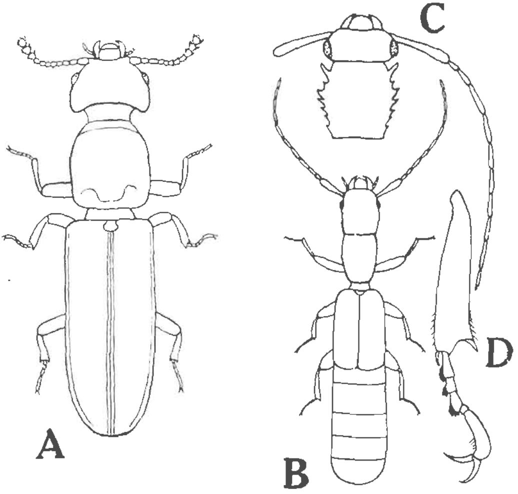


FIG. R25. A, *Dryocora walkeri* Lea, Tasmania, fam. Cucujidae, subfam. Silvaninae; length 4.5 mm. B, *Diagrypnodes wakefieldi* Waterh., New Zealand, fam. Cucujidae, subfam. Hemipeplinae; length 7 mm. C, *Brontes militaris* Er., Australia, fam. Cucujidae, subfam. Brontinae; head and prothorax; length of antenna 6 mm. D, *Parandra frenchi* Blkb., female, Australia, fam. Cucujidae, subfam. Parandrinae; middle tibia and tarsus; length 6 mm. [*R. J. T. del.*

Family 11. **Cucujidae** [Aus. 121, N.Z. 23]. This family is divisible into six well-marked subfamilies, each of which may perhaps be considered as of family rank. The Passandrinae are distinguished by the possession of large jugular plates which hide the maxillae; their antennae are strongly moniliform, their tarsi 5-5-5 in both sexes, the first segment short. The Australian *Hectarthrum brevifossum* Newm. (pl. 17, fig. 20) belongs to this group; it is a thick, subcylindrical beetle of a shiny black colour, and varies in length from 8 up to 22 mm. The Cucujinae have filiform or submoniliform antennae of normal length, with the scape not elongated; the tarsi are 5-5-5 in females, 5-5-4 in males. To this group belongs the

common Australian species *Platisus integricollis* Reitter, which is so excessively flattened that it is little thicker than a piece of stiff paper; these beetles are often found in company with their flat, elongate larvae under moist bark. *Ipsaphes* is an Australian genus containing some fine, flattened species with curious, bark-haunting larvae (fig. R9); *I. mocrosus* Pasc. is dull blackish, *I. bicolor* Oll. (pl. 17, fig. 19) black with reddish-brown elytra. The Brontinae differ from the Cucujinae in having the scape of the antennae elongated and the tarsi 5-5-5 in both sexes. The world-wide genus *Cryptamorpha*, with the antennae of normal length and the scape only moderately elongated, occurs in both countries. In *Brontes* and its close allies, the antennae are greatly elongated and the scape very long; one of the commonest species is the Australian *Brontes militaris* Er. (fig. R25, C). The peculiar Hemipeplinae resemble the Brontinae in the form of the antennae, but have the elytra greatly shortened; at first sight, they resemble Staphylinidae, but the lesser number of visible abdominal sternites will serve to distinguish them with ease; also their tarsi are 5-5-5 in females, 5-5-4 in males. To this group belong the very flattened Australian *Inopeplus dimidiatus* Waterh. and the New Zealand *Diagrypnodes wakefieldi* Waterh. (fig. R25, B); the former is associated with ants. The Silvaninae contain the smallest species of the family, in which the antennae are rather short and have the terminal segments somewhat swollen; the tarsi may be either 5-5-5 or 5-5-4 in the males; two of the best known genera are *Dryocora* (fig. R25, A) found in both countries in rotten wood, and the Australian *Lathropus*. The two Australian inquiline genera *Nepharis* and *Nepharina* contain some extraordinary forms of very small size, showing close affinity with the Colydiidae. *Nepharis alata* Cast. (pl. 16, fig. 3), a dull brown beetle with greatly expanded pronotum, is the most striking of these.

The Parandrinae contain the widespread genus *Parandra*, of which there exists a single Australian species, *P. frenchi* Blkb. (pl. 17, fig. 21). This genus has the antennae rather short, moniliform, without any lengthening of the scape; the tarsi are 5-5-5, with segs. 1-3 pubescent beneath and seg. 4 a small nodule, but quite visible to the naked eye; the two sexes differ greatly in form, the male having huge mandibles, and a much larger head and smaller body than the female. Lameere and others have placed this genus in the subfamily Prioninae of the Cerambycidae, in spite of its short antennae and 5-segmented tarsi; in our opinion, the genus is obviously Cucujoid, and should either form a distinct subfamily, as here placed, or else a distinct family by itself.

The introduced Saw-toothed Grain-beetle, *Silvanus surinamensis* L., a small, dull black beetle with the edges of the pronotum strongly toothed, is a world-wide pest of grain, flour and starch, and occurs commonly in both countries.

Superfamily VIII. COLYDIOIDEA.

This large group of small and mostly obscure forms includes the larger portion of the old Series Clavicornia. The Colydiidae stand nearest to the stem-form of the group, and need to be carefully studied, together with the Trogositidae and Cryptophagidae, as all three families show a fairly close approach to the Cucujidae. Two main lines of specialization should be noted within the group, (a) the tendency towards the adoption of the very convex, completely oval form, with pronotum wide behind and completely sessile on the elytra, and (b) the reduction in the number of tarsal segments. The most highly specialized forms are those in which both these tendencies have operated, e.g., the Coccinellidae and Corylophidae. The Heteroceridae are only doubtfully included here, their real affinities being problematical; the Lyctidae and Bostrichidae are highly specialized as borers. There are no less than sixteen families represented in Australia and New Zealand; these can be separated by the following Key:—

1. Tarsi actually or apparently 3-3-3. — 2
   Tarsi not as above. — 5
2. Very small beetles with tarsi actually 3-3-3; head free, pronotum narrower than elytra behind. — Fam. 24. LATHRIDIIDAE
   Tarsi apparently 3-3-3, but actually with a small nodule representing a fourth segment situated between the apparent second and third. — 3
3. Very convex, round or oval beetles with the head concealed beneath the prothorax; antennae short, not strongly clubbed. — 4
   Beetles rarely of above shape, usually with a distinct break in contour between pronotum and elytra; antennae longer, strongly clubbed. — Fam. 25. ENDOMYCHIDAE

4. Very minute beetles (1 to 1.5 mm. long) with first two segments of tarsi not pubescent beneath; hindwings narrow, with a fringe of long hairs. Fam. 27. CORYLOPHIDAE
Larger beetles (2 to 8 mm. long) with first two segments of tarsi pubescent beneath; hindwings not as above. Fam. 26. COCCINELLIDAE
5. Tarsi 5-5-5 (rarely 4-5-5 in males only); fourth segment often small or minute but always visible in preparations. 6
Tarsi 4-4-4 (rarely 3-4-4 in males only); true fourth segment (between third and apical segments) absent. 12
6. Boring beetles, with first segment of tarsus very short, more or less indistinctly separated from second. 7
Not borers; first segment of tarsus quite distinct. 8
7. Head prominent, not covered by prothorax; antennae with 2-segmented club. Fam. 21. LYCTIDAE
Head deflexed and protected by prothorax; antennae with 3-segmented club. Fam. 22. BOSTRYCHIDAE
8. All the coxae separate and having an external prolongation. Fam. 15. NITIDULIDAE
Coxae not as above. 9
9. Oval beetles with pronotum sessile on bases of elytra for their entire width. 10
Pronotum not as above. 11
10. Antennae short; tarsi with segs. 1-3 rather broad, pubescent beneath. Fam. 18. EROTYLIDAE
Antennae longer; tarsi with segs. 1-3 not pubescent beneath. Fam. 19. PHALACRIDAE
11. Fore and middle coxae separated, with external prolongations, hind coxae contiguous; antennae with the three apical segments enlarged only on the inner side, so as to form an asymmetrical club. Fam. 13. TROGOSITIDAE
Minute beetles with fore and middle coxae small, deeply embedded; antennae with a more or less symmetrical club; (tarsi of males sometimes 4-5-5). Fam. 14. CRYPTOPHAGIDAE
12. Antennae short, with a large serrated club formed by the seven terminal segments. Fam. 23. HETEROCERIDAE
Antennal club formed of three segments. 13
13. Fore and middle coxae small, globular, embedded. 14
Fore coxae oval. 15
14. The five visible sternites of abdomen all mobile. Fam. 16. CIIDAE
Some of the five visible sternites not mobile; hind coxae transverse. Fam. 12. COLYDIIDAE
15. Fore coxae exserted; antennae short, with definite club. Fam. 20. GEORYSSIDAE
Fore coxae not exserted; antennae less strongly clubbed. Fam. 17. MYCETOPHAGIDAE

Family 12. **Colydiidae** [Aus. 123, N.Z. 206]. Tarsi 4-4-4, all the segments narrow; antennae with club formed of either two or three segments; fore and middle coxae small, globular, embedded, hind coxae transverse; abdomen with five visible sternites, partially immobile. Mostly small beetles, with more or less elongate, cylindrical form, but often somewhat flattened or with bizarre sculpturing. They are attached to the primitive forests, living in leaf mould or decayed wood or under bark. Larvae cylindrical, with short legs and abdomen ending in a hard process or plate. New Zealand is the headquarters of the family, which is also well represented on Lord Howe Island. *Bothrideres* is a very characteristic genus found in both countries. *Deretaphrus* and *Meryx* are interesting Australian genera, the former elongate and cylindrical, the latter very distinctively sculptured. *D. ignarius* Pasc. (pl. 18, fig. 3), from Victoria, is the largest Australian species, measuring up to 12 mm. long. *Euclarkia* and *Kershawia* are curious Australian genera found in ants' nests; *K. ruficeps* Lea (pl. 16, fig. 9) is one of the best known species. The New Zealand species are arranged in numerous subfamilies and genera, the larger number being included in *Pycnomerus*, *Ulonotus*, *Notoulus*, *Ditoma* and *Coxelus*. *Tarphiomimus wollastoni* Sharp (fig. R26) is one of the most strikingly sculptured of them.

Family 13. **Trogositidae** [Aus. 38, N.Z. 23]. Tarsi 5-5-5, with basal segment very small, segs. 3 and 4 similar, seg. 5 long; hind coxae contiguous;

antennal club asymmetrical, formed by enlargement of the three apical segments on the inner side only. Larvae cylindrical, with short legs; mostly predaceous. The majority of species in both countries belong to the genus *Leperina* and are

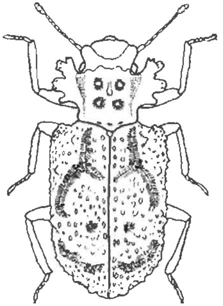


FIG. R26. *Tarphiomimus wollastoni* Sharp, New Zealand, fam. Colydiidae. Length 3.5 mm. [*A. Tonnoir del.*

fairly broad beetles with parallel-sided elytra, found under bark; they have a mottled or speckled coloration produced by an abundance of hairs and scales on pronotum and elytra. *L. nigrosparsa* Wh. (pl. 18, fig. 2) is a well-known New Zealand species; *L. decorata* Er. is a curiously marked species found in Tasmania and on Lord Howe Island. The Cadelle Beetle, *Tenebrioides mauritanicus* L. is a cosmopolitan species which has been introduced into both countries; its larva devours grain-insects, codling-moth larvae and other pests.

Family 14. **Cryptophagidae** [Aus. 8, N.Z. 28]. Tarsi 5-5-5, more rarely 5-5-4 in males only; antennae with 3-segmented club, symmetrical but not

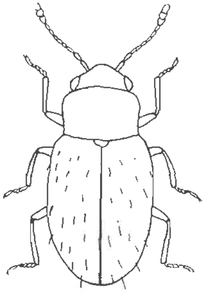


FIG. R27. *Cryptophagus rutilus* Broun, New Zealand, fam. Cryptophagidae. Length 1.5 mm. [*A. Tonnoir del.*

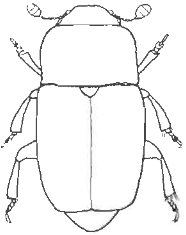


FIG. R28. *Carpophilus australis* Murray, Australia, fam. Nitidulidae. Length 3 mm. [*A. Tonnoir del.*

very compact; fore and middle coxae very small, deeply embedded; abdomen with five visible sternites, all movable, the first very long. Small or minute beetles which feed on fungi or live in flowers; larvae cylindrical, with short legs, mostly

scavengers in straw and refuse, or in nests of wasps, bees and gregarious caterpillars. *Telmatophilus* and *Cryptophagus* are the principal genera in New Zealand; *C. rutilus* Broun (fig. R27) is a shiny, dark brown species, 1.5 mm. long. Of the few Australian species so far described, *Cryptophagus globipennis* Blkb. and *Atomaria lindensis* Blkb. are the best known; there are a considerable number of undescribed species.

Family 15. **Nitidulidae** [Aus. 119, N.Z. 35]. Tarsi 5-5-5, the fourth segment shortest; antennal club well-formed, with three segments; all the coxae separated and prolonged externally; elytra frequently more or less abbreviated; abdomen with five visible sternites. Small beetles of variable habits, found in decaying vegetable matter, on flowers, in ripe fruit, or feeding in sap or on carcasses; larvae fusiform, with short legs. The genus *Carpophilus* is represented in Australia by a number of species, one of the commonest being *C. australis* Murray (fig. R28), a dark brown to blackish beetle with two pale brown marks on each elytron. *Macroura concolor* Macl. is a broadly oval, dull blackish species, 3 mm. long, found in Australia. *Pochadius pilistriatus* Macl., 4 mm. long, brown and hairy, feeds in the seed-cases of the Kurrajong tree (*Brachychiton*). *Ericmodes australis* Grouvelle is a very curious species which lives in the rust galls of *Uromycladium* on wattles (*Acacia*); it is very unlike the more typical members of the family. *Brachypeplus auritus* Murray (pl. 16, fig. 11) is a curious little black and gold species, 4 mm. long, with shortened elytra; it lives in the nests of the small native Australian bees of the genus *Trigona*. The best known genera in New Zealand are *Soronia* and *Epuraea*, both also found in Australia and elsewhere. Introduced species of *Carpophilus* attack damaged fruit in both countries.

Family 16. **Ciidae*** [Aus. 13, N.Z. 23]. Tarsi 4-4-4, short; antennae short, with 3-segmented club; fore and middle coxae small, oval, deeply embedded; abdomen with five visible sternites, all movable. An armature of horns often present either on head or pronotum or both. Larvae cylindrical, with short legs; abdomen ending in one or two hooks or a hard plate. Small to minute beetles found feeding on fungi or living in decayed wood. All the New Zealand species belong to the genus *Cis*, which is also represented in Australia. *Orophius* and other genera found in Australia have scarcely been studied as yet, and a number of species remain to be described.

Family 17. **Mycetophagidae** [Aus. 13, N.Z. 10]. Tarsi of female 4-4-4, of male 3-4-4; club of antenna 3-segmented, not stout; coxae oval, not deeply embedded; abdomen with five visible sternites, all movable. Larvae cylindrical

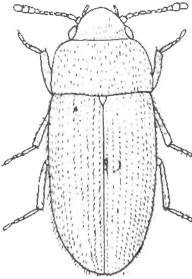


FIG. R29. *Typhaea hirta* Broun, New Zealand, fam. Mycetophagidae. Length 2.5 mm. [*A. Tonnoir del.*

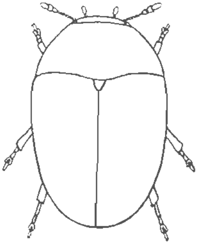


FIG. R30. *Litochrus maculatus* Blkb, Australia, fam. Phalacridae. Length 2.3 mm. [*A. Tonnoir del.*

or subcylindrical, with very small legs; feeding on fungi in wood, etc. Small, inconspicuously coloured beetles, somewhat elongate in shape. *Triphyllus* and *Typhaea* are the chief genera represented. *Typhaea hirta* Broun (fig. R29) is

*Greek *kis* a weevil or wood-worm, gen. *kios*, stem *ci*, hence Ciidae, not Cioidae as usually given.

a New Zealand species, brown, covered with delicate hairs. The Australian *Triphyllus intricatus* Blkb., 3 mm. long, is brownish with darker pattern on elytra.

Family 18. **Erotylidae** (Fungus Beetles) [Aus. 73, N.Z. 10]. Tarsi 5-5-5, with seg. 4 usually very small, segs. 1-3 somewhat broadened, pubescent beneath; club of antenna 3-segmented, stout; fore and middle coxal cavities round, not prolonged externally; abdomen with five visible sternites. Larvae subcylindrical, legs reduced or absent. Small to medium-sized beetles, mostly elongate-oval in form and often prettily coloured. *Episcaphula* and *Thallis* are the principal genera in Australia; *E. nigrofasciata* Blkb. (pl. 15, fig. 4), *E. australis* Bd. and *E. pictipennis* Crotch are all well-known and handsome species, while *E. hercules* Lea is the giant of the family, measuring up to 23 mm. in length. *Thallis compta* Er., 6 mm. long, is a beautiful orange-red species with black spots. New Zealand possesses five small species of *Cryptodachne*.

Family 19. **Phalacridae** [Aus. 48, N.Z. 0]. Tarsi 5-5-5, seg. 4 small and obscure; club of antenna 3-segmented, slight; fore coxae globular; hind coxae contiguous; abdomen with five visible sternites. Small or minute, compact, oval beetles with elytra completely covering abdomen. Larvae subcylindrical, with short legs; living in flower-heads. All the species are convex, glossy beetles, 3 mm. or less in length, and without any striking features; they are often mistaken for small water-beetles. *Litochrus maculatus* Blkb. (fig. R30), one of the best-known Australian species, is shiny black with a pair of bright brown spots, conjoined, in middle of elytra. *Parasemus victoriensis* Blkb., 2.5 mm. long, is dark reddish, with black prothorax.

Family 20. **Georyssidae** [Aus. 2, N.Z. 0]. Tarsi 4-4-4; antennae short, with well-formed, 3-segmented club; fore coxae exserted, not touching. Small beetles found in muddy or moist sandy places. Both the Australian species belong to the genus *Georyssus*.

Family 21. **Lyctidae** [Aus. 3, N.Z. 0]. Tarsi 5-5-5, the first segment very short and imperfectly separated from the second; head prominent, not covered by prothorax; antennal club with only two segments; fore coxae contiguous, very slightly transverse; abdomen with five visible sternites. Larvae fleshy, wood-boring grubs with short legs and abdomen curved distally. A small family, considered by many authors as a subfamily of the next. The native Australian species belong to the genus *Lyctus*. The destructive "Powder-post Beetle," *Lyctus brunneus* Steph., is an introduced species which attacks dry wood in both countries and is abundant in post and railings; it is somewhat elongate in form, reddish brown, about 4 mm. long.

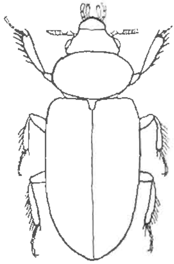


FIG. R31. *Heterocerus flindersi* Blkb., Australia, fam. Heteroceridae. Length 4 mm. [*A. Tonnoir del.*

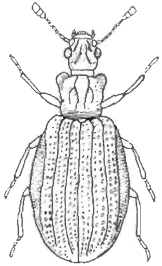


FIG. R32. *Lathridius costulatus* Broun, New Zealand, fam. Lathridiidae. Length 2 mm. [*A. Tonnoir del.*

Family 22. **Bostrychidae** (Auger Beetles) [Aus. 40, N.Z. 2]. Characters as in Lyctidae, but head more or less completely hidden beneath prothorax, club of antenna with three segments, and elytra strongly truncated be-

hind and often armed with spines. The larvae are destructive borers in timber and forest trees. The largest of the Australian species is *Bostrychopsis jesuita* Fabr. (pl. 18, fig. 4), about 12 mm. long, black and rugose; it damages the stems of fruit-trees. *Xylion collaris* Er., 5 to 7 mm. long is shining black with reddish-brown pronotum. *X. cylindricum* Macl., dark brown and a little larger, damages wine-casks. *Xylobosca bispinosa* Macl. is one of the most extraordinary of the Australian species; the two sexes are very distinct, and the male guards the female during oviposition. The New Zealand species belong to the genus *Apate*. During the Great War, the introduced *Rhizopertha dominica* Fabr. was a serious pest of stored wheat in Australia.

Family 23. **Heteroceridae** [Aus. 9, N.Z. 0]. Tarsi 4-4-4; antennal club with seven segments, broad and serrate; legs armed with stout spines; head with projecting labrum and mandibles. Larvae with stout thorax, well developed legs and narrower abdomen; living in burrows in mud or wet sand. Small beetles found in the same places as the larvae. Most of the Australian species belong to *Heterocerus*. *H. flindersi* Blkb. (fig. R31) is 4 mm. long, with blackish head and pronotum, and elytra dull greyish, pubescent. The affinities of this curious family are very problematical; they have a general resemblance to Dryopidae.

Family 24. **Lathridiidae** [Aus. 34, N.Z. 54]. Tarsi 3-3-3; antennal club 3-segmented; head free; pronotum narrower than elytra behind; fore coxal cavities round, not prolonged externally; abdomen with five visible sternites, all movable. Larvae fusiform, with short legs. Small to minute beetles (3 mm. long or less), found chiefly in moss, flowers, and fallen leaves. *Lathridius* and *Corticaria* are the principal genera represented; *L. costulatus* Broun (fig. R32) is a handsomely sculptured New Zealand species.

Family 25. **Endomychidae** [Aus. 28, N.Z. 0]. Tarsi apparently 3-3-3, but there is a small nodule between the second and distal segments representing the true third segment; antennae rather long, with well-developed 3-seg-

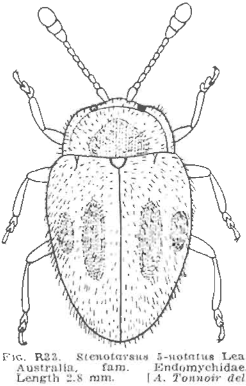


FIG. R33. *Stenotarsus 5-notatus* Lea, Australia, fam. Endomychidae. Length 2.8 mm. [*A. Tonnoir del.*

mented club, the apical segment large and rounded; fore and middle coxae globular; abdomen with five visible sternites and vestiges of a sixth at apex. Larvae moderately broad, mostly feeding on fungi. This family comprises small but beautiful species which feed on fungi in wood. The principal genus in Australia is *Stenotarsus*, containing broadly oval, convex beetles 2 to 3 mm. long. *S. 5-notatus* Lea (fig. R33) is orange-red, hairy, with black spots or blotches on pronotum and elytra; *S. arithmeticus* Blkb. has the figure "3" on each elytron.

Family 26. **Coccinellidae** (Lady-birds) [Aus. 256, N.Z. 25]. Closely related to the preceding family, but much more convex and rounded in form;

arsi as in Endomychidae, but with segs. 1-2 pubescent beneath; head concealed beneath prothorax; antennae shorter than in Endomychidae. Larvae moderately broad across thorax, the abdomen tapering distally; legs well developed; integument dark or with a conspicuous colour-pattern. Pupae somewhat obtected, attached by end of abdomen so as to hang downwards like those of Nymphalid Butterflies.

The Coccinellinae are highly beneficial insects which feed voraciously, both in the larval and imaginal stages, upon aphides and scale-insects. *Coccinella transversalis* Fabr. is a widely distributed species found in Australia; *C. tasmani* Wh. is a small black species with red spots, found in New Zealand; *C. 11-punctata* L. is an introduced European species, red with black spots, common in New Zealand, but, unfortunately, heavily parasitized. The genus *Scymnus* contains about 60 Australian and 15 New Zealand species, mostly very small, dull blackish or brownish beetles, which feed on larval Psyllids, mites, etc. *S. vagans* Blkb. is black, only 1 mm. long, and feeds on the eggs of Red Spider; its life-history has been worked out by Lea in Tasmania. *Orcus* contains brightly metallic species, sometimes spotted; *O. chalybeus* Bd. (pl. 15, fig. 5), the Steel-blue Lady-bird, is a valuable Australian species which has been introduced into New Zealand, but will only stand the warmer climate of the Auckland Province; it does useful work in helping to control scale-insects on citrus trees and oaks. *Rhizobius* is an extensive genus containing 60 Australian species, mostly of dull colouration. *Rh. ventralis* Er. has been introduced into New Zealand to help to control the Blue-gum Scale (*Eriococcus coriaceus* Mask.) and has been very successful, exterminating this scale over large areas; it also feeds on many other species of scale-insects. *Novius* (*Vedalia*) *cardinalis* Muls. is a small Australian lady-bird, black with red markings, famous for its wonderful work in controlling the Cottony-cushion Scale (*Icerya purchasi* Mask.) in California, South Africa, and New Zealand; at the present time, this scale, instead of being a scourge, is barely able to exist in obscure corners, each new colony being rapidly attacked and destroyed by the lady-bird. The largest species of the subfamily is the Australian *Neda princeps* Muls. The genus *Cryptolaemus* contains Australian species which feed on mealy-bug and have their larvae covered with a whitish meal and carrying white processes, so as to resemble their prey. *C. montrouzieri* Muls. is a dull blackish species, 4 to 5 mm. long, with obscure brown markings; it has been introduced into California and Hawaii, and has proved very successful in controlling various species of mealy-bug (genus *Pseudococcus*) there; so far, the attempt to acclimatize it in the orchard districts of New Zealand has not met with any marked success, as it cannot stand the cold winters.

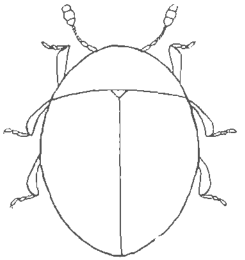


FIG. R34. *Corylophodes nigellus* Broun, New Zealand, fam. Corylophidae. Length 1.3 mm.
[*A. Tonnoir del.*

Many of the above species are amongst the most important of all beneficial insects, and their introduction and propagation in infected districts is one of the principal tasks of the economic entomologist.

The Epilachninae are somewhat larger lady-birds, about 8 mm. in length, which are vegetable feeders, the adult beetles in particular doing great damage to Solanaceous plants. They are found in the warmer parts of Australia, but are absent from New Zealand, Tasmania, and Victoria. The commonest species are *Epilachna 28-punctata* Fabr. and *E. guttato-pustulata* Fabr.

Family 27. **Corylophidae** [Aus. 36, N.Z. 14]. Tarsi 4-4-4 but apparently only 3-segmented, seg. 3 being a small nodule concealed in the end of seg. 2; antennae often hairy, the club loose, 3-segmented, well-formed; maxillae with a single lobe only; hindwings narrow, with a fringe of long hairs; abdomen with six visible sternites. Small beetles, 1 to 1.5 mm. long, of perfect oval shape and strongly convex; the sides of the pronotum are often produced backwards so as to embrace the elytra. *Sericoderus* and *Corylophodes* are genera common to both countries; *C. nigellus* Broun (fig. R34) is a shining black New Zealand species, 1.3 mm. long by 1 mm. wide.

Superfamily IX. BYRRHOIDEA (BRACHYMERA).

This small group is closely related to the foregoing, but differs from it in having the hind coxae formed to receive the femur when retracted; this character is only one out of a number correlated with the general habit which these insects have, when alarmed, of contracting all their appendages (antennae included) into complete apposition with the body. Tarsi 5-5-5, the first four segments very short. Antennae variable. Abdomen with five visible sternites. The two families included in this group can be separated as follows:—

Very rounded, almost spherical beetles; head retracted beneath prothorax (except in *Nosodendron*); no ocellus present; fore coxae transverse; abdomen with first three visible sternites fixed. Fam. 29. BYRRHIDAE

Beetles of variable shape, with the head small, deflexed, but not retracted beneath prothorax; an ocellus present, except in *Dermestes*; fore coxae oblique; elytra usually hairy or scaly; abdomen with all five visible sternites free. Fam. 28. DERMESTIDAE

Family 28. **Dermestidae** [Aus. 60, N.Z. 10]. A single median ocellus present on frons (except in *Dermestes*); antennae short, sometimes clubbed, fitting into a hollow of the prothorax. Small, hard, dull-coloured beetles with hairy or scaly elytra. Larvae active, hairy, with well-formed legs; feeding on dried animal matter, hairs, fur, etc., and often injurious. The most abundant genus is *Trogoderma*, with clubbed antennae and very distinct ocellus; the Australian *T. morio* Er. (fig. R35) is entirely black and covered with fine hairs. Of introduced species, *Dermestes vulpinus* Fabr. is found under dead animals; *D. lardarius* L., the Bacon Beetle, is a pest in meat pantries; two or three introduced species of *Anthrenus* (Museum Beetles) also occur, doing great damage to museum specimens, insect collections, etc., especially in Australia; the most destructive of these is *A. varius* Lea.

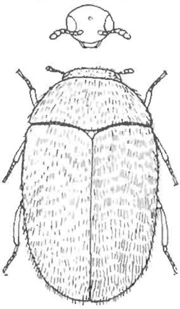


FIG R35.
Trogoderma morio Er., Australia, fam. Dermestidae. Length 4mm. Above, front view of head, showing ocellus.
[*A. Tonnoir del.*

Family 29. **Byrrhidae** (Pill Beetles) [Aus. 46, N.Z. 51]. Head completely retractile, except in *Nosondendron*; no ocellus present; all the appendages capable of complete apposition to the body; antennae very variable. Small to medium, very convex, almost spherical beetles, dull or brightly coloured. Larvae soft, cylindrical, with short legs. The most abundant genus in both countries is *Pedilophorus*, which includes a number of Australian and Tasmanian species of metallic colouring and great beauty, the finest being *P. gemmatus* Lea (pl. 15, fig. 6), brilliant green with orange-red embossments on the elytra; *P. humeralis* Broun is a New Zealand species 7 mm. long, broadly oval, dull blackish. Other genera represented are *Curimus* and *Liochora*. Two species of the peculiar genus *Nosodendron* occur in New Zealand.

Superfamily X. HISTEROIDEA.

This is a small group containing only the very distinct and isolated family Histeridae, considered by some authors as belonging to the Staphylinoidea, by others to the old series Clavicornia, but actually not closely related to either. The group is characterized by the very compact shape (usually broadly oval, squarish, or cylindrical, and either flat or very convex), with legs and usually also head retractile; the elytra close-fitting, hard, and truncated behind so as to leave pygidium and propygidium exposed; the antennae short, retractile, with long, curved scape followed by seven short segments and ending in a huge capitate club of three segments (fig. R36); the fore coxae strongly transverse, the others oval and widely separated; abdomen with five visible sternites, and, on removal of elytra and wings, seven visible tergites, all hard; tarsi 5-5-5; larvae cylindrical, with short legs.

Family 30. **Histeridae** [Aus. 122, N.Z. 21]. Small to medium-sized beetles,

predaceous or carrion-feeders; a number of the Australian species are found in ants' nests. The finest and most primitive genus is the Australian *Hololepta*, in which the head is exposed and the body very flat. *H. sidnensis* Mars. (pl. 18, fig. 1) is shining black, half-an-inch long, with strong, forcipate mandibles projecting in front of the small head; it is found in the rotting cores of dead grass-trees (*Xanthorrhoea*). *Sternaulax zelandicus* Mars., known in New Zealand as the "Tortoise Beetle," is 8 mm. long, shiny black and much less flattened; the tibiae are very spiny. *Saprinus* is a cosmopolitan genus of carrion-feeders, convex, rounded, of smaller size and metallic colouring, found in both countries. The handsome *S. australasiae* Blkb. has a bronze pronotum and deep metallic blue elytra; this and *S. laetus* Er. are the best known of the Australian species. *S. pseudocyaneus* Wh. (fig. R36), deep metallic black, is a New Zealand species.

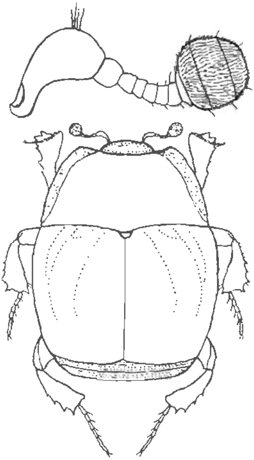


FIG. R36. *Saprinus pseudocyaneus* Wh., New Zealand, fam. Histeridae. Length 4 mm. Above, antennae, enlarged.
[*R. J. T. del.*

The ants' nest species are very rare and greatly prized by collectors; they measure up to 4 mm. long, and are of bizarre form. The principal genus is *Chlamydopsis*, of which a number of species have been described, one of the finest being *Ch. agilis* Lea (pl. 16, fig. 10). Other genera are *Pheidolephila* and *Ectatommiphila*.

Superfamily XI. STAPHYLINOIDEA.

This group contains a number of families of very diverse appearance, but all united by the form of the labium (fig. R37), in which the submentum is wide and carries in front a membranous piece from which the prominent labial palpi arise, and, behind these, the bilobed ligula. In all except the Trichopterygidae, (and wingless species of other families), the venation of the hindwing is characteristic; there is a strong pterostigma, often placed before half-way, and the returning vein is either absent, or small and closer to the base of the wing than usual; in all cases, *M* runs as a strong vein to the wing-border. The folding of the hindwing is also without parallel in other groups, there being two main folds, of which the more basal one has its axis placed before the pterostigma. The antennae and tarsi are highly variable. The great majority of the species have shortened elytra, but these organs are never soft, as in Lampyroidea; the number of visible sternites varies from five to seven. The Trichopterygidae are an isolated and highly reduced family whose affinities appear to be Staphylinoid; they are so minute as to render their study extremely difficult. The following Key will distinguish the families:—

1. Elytra either covering the abdomen, or, if shortened, leaving less than half the abdomen uncovered. 2
   Elytra greatly shortened, leaving more than half the abdomen uncovered.* 5
2. Excessively minute, oval or rounded, beetles (0.2 mm. to 2 mm. long), the hindwings very narrow, fringed with long hairs; tarsi 3-3-3.
   Fam. 36. TRICHOPTERYGIDAE
   Not such beetles. 3

*A few Staphylinidae having less than half of the abdomen exposed can be recognized by their six or seven visible sternites, all freely movable.

3. Hind coxae contiguous, abdomen usually with only five visible sternites. Fam. 31. SILPHIDAE
Hind coxae separated; abdomen with six visible sternites. 4
4. Eyes coarsely granulated; fifth visible sternite not exceptionally large; hindwings absent. Fam. 33. SCYDMAENIDAE
Eyes normal; fifth visible sternite conical, as long as sternites 2-4 together, the sixth minute; hindwings present. Fam. 32 SCAPHIDIIDAE
5. Abdomen flexible, usually slender, with 6-7 visible sternites. Fam. 34. STAPHYLINIDAE
Abdomen rigid, usually with only five visible sternites (rarely six); beetles usually of broader form than above. Fam. 35. PSELAPHIDAE

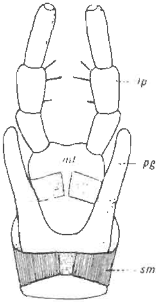


FIG. R37. Labium of *Staphylinus huttoni* Broun, New Zealand, fam. Staphylinidae. (x 40). *lp*, labial palp; *ml*, mentum; *pg*, paraglossa; *sm*, submentum. [*R. J. T. del.*

Family 31. **Silphidae** [Aus. 38, N.Z. 43]. Beetles of broad form, with elytra either completely covering abdomen or slightly shorter, exposing the pygidium; antennae variable, often with enlarged distal segments; fore coxae conical, contiguous; hind coxae transversely placed, contiguous; tarsi 5-5-5 or 4-4-4; abdomen usually with five visible sternites. Larvae of broadly oval form, active, with well-developed legs; feeders on carrion or decaying vegetable matter, more rarely predaceous.

The majority of the species are small and obscure, and there are many Australian forms not yet described. The Burying Beetles (*Necrophorus* and allies) belong to this family; they are well-known for their habit of digging around dead birds and small mammals until they succeed in completely burying them; they then lay their eggs on the carcass, on which the larvae feed. These beetles are of robust form, and have the pygidium exposed. *Necrodes osculans* Vigors is a fine species over an inch long, with two irregular patches of orange-brown crossing each elytron; it has been introduced into North Queensland. *Necrophilus prolongatus* Sharp is a New Zealand species about half-an-inch long, blackish with brown edging to pronotum. Most of the New Zealand species belong to the genera *Choleva* and *Mesocolon*. The largest of the Australian species is the curious *Ptomaphila lachrymosa* Schr. (pl. 17, fig. 24), dull brown in colour, with darker oval warts on the large elytra; it is frequently found under dead animals in the bush. A few rare Australian species occur in ants' nests; these belong to the genera *Clambus*, *Anisotoma* and *Myrmicholeva*.

Family 32. **Scaphidiidae** [Aus. 22, N.Z. 19]. Small beetles allied to the Silphidae, but distinguished by having the hind coxae separate and the abdomen with six visible sternites, of which the fifth is very long and conical, the sixth small. Antennae variable, usually with some of the distal segments thickened; tarsi 5-5-5; elytra either covering the abdomen or somewhat shortened; hindwings well developed. Larvae, as far as known, subcylindrical, with short legs. These beetles are found on flowers and under bark. *Scaphidium* and *Scaphisoma* are the principal genera in both countries; the former has the elytra shortened, the latter has them entirely covering the abdomen. *Scaphisoma concinnum* Broun is a brownish New Zealand species, 3 mm. long, with blackish marks at bases of elytra. *Scaphidium alpicola* Blkb. (fig. R38) is a handsome Australian species prettily marked in black and bright red.

Family 33. **Scydmaenidae** [Aus. 77, N.Z. 50]. Small or minute beetles allied to the previous two families, but distinguished by their general form, which is that of Pselaphidae but with complete elytra, and by the possession of coarsely granulated eyes. Antennae usually moniliform, but with the segments increasing in width from base to near apex; tarsi 5-5-5; hindwings absent; abdomen with six visible sternites, the fifth not long and conical as in Scaphidiidae. Larvae unknown. The two principal genera in both countries are *Scydmaenus* and *Phagonophana*. *Ph. alacer* Broun (fig. R39), black with shiny dark reddish-brown elytra, is one of a number of inconspicuous New Zealand species. A number of Australian species of both genera occur in ants' nests; three of the finest of these are *Ph. kingi* King, *Ph. macrosticta* Lea and *Ph. latipennis* Lea, the last

being 3 mm. long, reddish-brown. *Heterognathus geniculatus* King (pl. 16, fig. 7) has very peculiar antennae in the male.

Family 34. **Staphylinidae** (*Rove Beetles*) [*Aus.* 617, *N.Z.* 204]. Mostly slender, more or less cylindrical or flattened beetles having (with few exceptions*) very short elytra exposing more than half the abdomen; abdomen flexible,

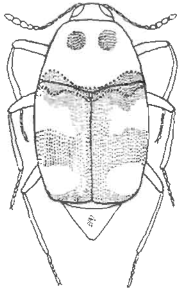


FIG. R38. *Scaphidium alpicola* Blkb., Australia, fam. Scaphidiidae. Length 5.5 mm. [*A. Tonnoir del.*

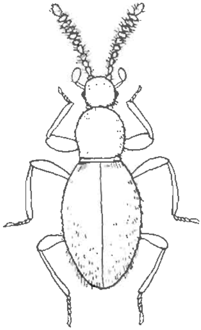


FIG. R39. *Phagonophana alacer* Broun, New Zealand, Scydmaenidae. Length 2.5 mm. [*A. Tonnoir del.*

often capable of being turned up at the tip, and having 6-7 visible sternites; submentum wide; ligula membranous, strongly bilobed; tarsi variable, with from five to three segments, not always the same on all three pairs of legs. Larvae active, caraboid, scavengers of decaying animal or vegetable matter; in shape, closely resembling the imagines without their elytra. These beetles are mostly small to medium in size, active, ground-scavenging, usually dull in colour. The family is a large one, divided into numerous subfamilies, of which we can only notice the more important ones.

The Aleocharinae have the prothoracic spiracles visible and the antennae inserted just internally to the eye-margins. The principal genera in both countries are *Calodera*, *Tachyusa*, *Homolota*, *Polylobus*, and *Gyrophaena*, containing small to minute, dull-coloured insects. Australian species of this group are often taken in ants' nests; the genera *Dabra* and *Dabrosoma* are true inquilines of ants' nests, while *Termitophila* inhabits the nests of white-ants. The Tachyporinae have the antennae inserted on the lateral borders of the frons; they are represented in both countries by numerous small species of *Conosoma*.

The Staphylininae are the dominant group and include many species of fairly large size, up to an inch long; they differ from the two previous groups in having the antennae inserted on the anterior border of the clypeus. Genera found in both countries are *Quedius*, *Staphylinus*, *Xantholinus*, *Cafius* and *Othius*. *Staphylinus huttoni* Broun (pl. 17, fig. 27) is a rather broadly built New Zealand species found under kelp on the sea-shore; other maritime New Zealand species are *Cafius littoreus* Broun and *C. maritimus* Broun. The Australian "Devil's Coachhorse," *Creophilus erythrocephalus* Fabr. (fig. R40, A) is a comparatively broad, black species with a large red head. The Australian genus *Actinus* contains exceptionally fine species with metallic head, pronotum and elytra; *A. imperialis* Fvl. and *A. macleayi* Oll. (pl. 17, fig. 25) have brilliant purple elytra. *Mysolius chalcopterus* Oll. is another fine species, 15 mm. long, with black body and brilliant bronze elytra.

All the other subfamilies have the prothoracic spiracles hidden. The Paederinae are represented in Australia by a number of common species of *Paederus*, narrow cylindrical forms, usually black with convex, red prothorax, such as *P. sparsus*

**Sartellus signatus* Sharp, a small, yellow, oval species found under carrion on Australian sea-beaches, has much longer elytra and is very unlike a typical Staphylinid.

Fvl. (pl. 17, fig. 26). 10 mm. long. *P. cruenticollis* Germ. is somewhat smaller, with steel-blue elytra and a red band across abdomen. These insects occur in damp places. *Hyperomma* is the principal New Zealand genus of this group. The Leptochirinae include the fairly large, black *Leptochirus samoensis* Blanch., found from Samoa to North Queensland. The Homaliinae (Omaliinae) are remarkable in possessing two ocelli on the frons (fig. R40, B); the small species of the genera

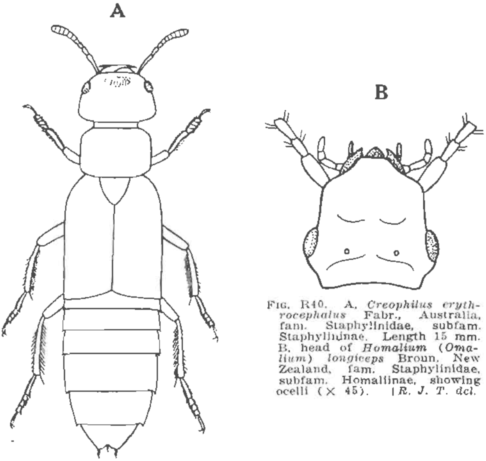


FIG. R40. A, *Creophilus erythrocephalus* Fabr., Australia, fam. Staphylinidae, subfam. Staphylininae. Length 15 mm. B, head of *Homalium* (*Omalium*) *longiceps* Broun, New Zealand, fam. Staphylinidae, subfam. Homaliinae, showing ocelli (× 45). [R. J. T. del.

Homalium (*Omalium*) and *Ischnoderus* are abundant in both countries, and one of the former has been taken on Macquarie Island.

This family probably contains more true inquilines than any other, but most of them are not very striking. The tiny *Glyptoma kingi* Lea, 2 mm. long, is a narrow cylindrical beetle, brown in colour, with sculptured head and prothorax and longitudinally ridged elytra, suggestive of the Colydiidae.

Family 35. **Pselaphidae** [Aus. 468, N.Z. 361]. Small to minute beetles allied to the previous family, with which they agree in the greatly shortened elytra; abdomen rigid, with five, rarely six, visible sternites; tarsi with three segments or less; antennae frequently reduced, sometimes even to a single segment; general shape proportionately broader than in Staphylinidae. Many species can be collected by sifting leaf-mould, moss or tussocks. Most of the species are dull, but a few are brightly coloured, such as the red *Pselaphus lineatus* King, fairly common in Australia; many of the forms are beautifully sculptured. The more typical species belong to the subfamily Pselaphinae, with normal antennae, clubbed or moniliform. *Pselaphus*, *Eupines*, *Sagola* and *Euplectus* are found in both countries. *Hametulus robustus* Broun (fig. R41), 2.5 mm. long, is a rich brown, New Zealand species with peculiar palpi. *Palimbolus* contains the largest Australian species, up to 4 mm. long. *Daveyia mira* Lea (pl. 16, fig. 5), little more than 1 mm. long, and *Leanymus mirus* Lea (pl. 16, fig. 4) are interesting inquilines. Many other Australian genera contain inquilines of distinctive appearance, such as *Tmesiphorus*, *Tyromorphus*, *Euplectops*, *Braxis*, *Gerallus*, *Somatopion*, and *Margaris*. The Clavigerinae, absent from New Zealand, are remarkable forms found in ants' nests; the antennae are reduced to one or two segments. The best known genus is *Articerus*, with elongate head, unsegmented tarsi, and antennae with only the elongated scape present and appearing as if broken off distally; *A. foveicollis* Raff. (pl. 16, fig. 6) is brown, 2 to 2.5 mm. long.

Family 36. **Trichopterygidae (Ptiliidae)** [Aus. 7, N.Z. 7]. Exceedingly minute beetles, with elytra almost or completely covering abdomen; tarsi 3-3-3; hindwings very narrow, fringed with long hairs. This family contains the smallest known beetles, ranging down to 0.2 mm. long; the largest is barely 2 mm. long. Their affinities are somewhat problematical, but the form of the mouth-parts, and especially the labium, indicates a connection with Staphylinidae.

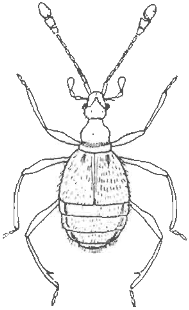


FIG. R41. *Hamotulus robustus* Broun, New Zealand, fam. Pselaphidae. Length 2.5 mm. [*A. Tonnoir del*

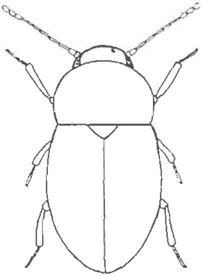


FIG R42. *Ptenidium lawsoni* Matt., New Zealand, fam. Trichopterygidae. Length 0.8 mm. [*A. Tonnoir del.*

The antennae have a 3-segmented club, as in Colydioidea; this and the rounded shape and small size give these insects a close resemblance to the Corylophidae; but the two families are by no means closely allied. *Ptenidium* is an interesting genus with four species in New Zealand, *P. lawsoni* Matt. (fig. R42), black with dark brown elytra, being the best known. Six of the Australian species belong to the blind genus *Rodwayia*, found in ants' nests; *R. orientalis* Lea (pl. 16, fig. 8) is brown, 0.8 mm. long. This genus is allied to the North American *Limulodes*.

Superfamily XII. LAMPYROIDEA* (MALACODERMATA).

The beetles included in this group are more or less elongate in shape and have the cuticle and elytra markedly softer than usual, the latter being loosely fitted, with little or no coadaptation with the abdominal segments. With the exception of the Melyridae, in which the venation is of a more specialized and reduced type, the hindwing has a very distinct and characteristic venational scheme (fig. R5), with long, well-formed apertum and returning vein, and with Cu_2 and the anal veins well developed; only the apical portion is folded. Tarsi usually 5-5-5, sometimes 4-4-4, rarely 4-5-5 in males only. Some of the forms have shortened elytra, but can be at once distinguished from Staphylinoidea by the softness of these organs. The group is mimicked by certain Tenebrionoidea which possess the soft cuticle and elytra as well as the general build and colouration of their models; they can, however, be distinguished at once by their tarsal formula 5-5-4. The Dascillidae, which also have rather soft cuticle and elytra, are distinguished by their more robust and rounded build and by a number of other important characters. Four families are recognized, which may be separated as follows:—

1. Excessively slender, elongate beetles, having the tarsi longer than the tibiae and all their segments without flaps. Fam. 40. LYMEXYLIDAE
   Moderately slender and elongate forms, with the tarsi shorter than the tibiae (tarsal segments with or without flaps). 2
2. *Clypeus not present as a distinct and separate plate; abdomen usually* with seven visible sternites, rarely with six. Fam. 37. LAMPYRIDAE

*See footnote on p. 212.

Clypeus present as a distinct plate, separate from the frons; abdomen with 5-6 visible sternites. 3

3 Tarsi always 5-5-5, filiform. Fam. 38. MELYRIDAE
Tarsi 5-5-5 or 4-4-4, not filiform, but with one or more segments carrying flaps beneath, and at least one segment bilobed. Fam. 39. CLERIDAE

Family 37. **Lampyridae (Telephoridae, Malacodermidae*)** (Fireflies, Glow-worms, Soldier Beetles). [Aus. 201, N.Z. 17]. Antennae variable nearly always 11-segmented; clypeus not distinct from frons; fore and middle coxae subconical, hind coxae transversely placed, prolonged internally; tarsi 5-5-5, rarely 4-5-5 in males only, always without flaps below; abdomen with seven visible sternites (rarely six), all movable except the first. Elongate, slender beetles with very soft cuticle and elytra, the latter not coadapted with the abdomen. Larvae more or less flattened, with small head and well-developed legs; thoracic and abdominal segments provided with hard dorsal plates; food variable, but many forms are highly carnivorous.

The Telephorinae appear to be the most primitive subfamily, as they have an undivided prothorax and elytra without complex sculpturing, and none of them produce light. They are well represented in Australia by species of *Heteromastix*, *Telephorus* and *Selenurus*. The males of *Heteromastix* often have antennae of extraordinary form. *Telephorus nobilitatus* Er. is a common species, 8-12 mm long, with orange-red pronotum and dark olive elytra. The few New Zealand species known are placed in the genus *Asilis*.

The Lycinae have the prothorax divided and the elytra marked with a very

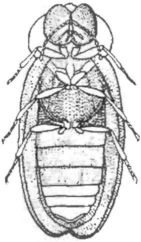


FIG. R43. *Atyphella brevis* Lea, male, Australia, fam. Lampyridae, subfam. Lampyrinae. Length 5 mm. Ventral view, showing the three terminal phosphorescent sternites (white). [*A. Tonnoir del.*

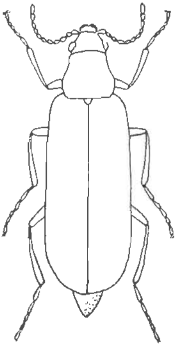


FIG. R44. *Dasytes anacharis* Broun, New Zealand, fam. Melyridae, subfam. Melyrinae. Length 6 mm. [*A. Tonnoir del.*

distinct clathrate (cancellate-striate) sculpture. The principal Australian genus is *Metriorrhynchus*, with about eighty species, mostly of red or black colouration, and some having a long rostrum resembling that of the Curculionidae. *M. rhipidius* W.S.M. (pl. 18, fig. 6) and *M. rufipennis* Fabr. are very common species with red elytra; the latter has been introduced into New Zealand, where no native species of this group occur. The larva (fig. R10) is black, and preys on other insect larvae and pupae. The many variations of this species are closely copied by the Oedemerid beetles *Pseudolycus haemorrhoidalis* Fabr. and *Ps. haematopterus* Guer., while the resemblance between *M. batesi* Lea and *Ps.*

*The family name Malacodermidae cannot stand, as it is not derived from any known genus; thus the family and superfamily must receive names derived from one or other of the two principal genera *Lampyris* or *Telephorus*.

wallacei Lea is even closer. The model (*Metriorrhynchus*) is highly distasteful to birds, and is mimicked not only by species of Oedemeridae, but also by beetles belonging to the Cantharidae, Cerambycidae, Buprestidae and Curculionidae, as well as by certain moths, flies and wasps. Other allied genera are *Trichalus* and *Calochromus*.

In the Lampyrinae, the abdomen is partly phosphorescent during life, and the females are often wingless or larviform. The Australian Fire-flies of the genera *Atyphella* and *Luciola* belong to this group; these are mostly tropical or sub-tropical, the most southern species being *A. lychnus* Oll.; *A. brevis* Lea (fig. R43) is an allied species with prettily striped, brownish elytra. It should be noted that this subfamily is absent from New Zealand, and that the so-called "glow-worms" of both New Zealand and Australia are larvae of Mycetophilid Diptera.

Family 38. **Melyridae (Malachiidae)** [Aus. 216, N.Z. 35]. Closely allied to the previous family, from which they differ in having only six visible abdominal sternites and also in the clypeus being distinctly marked off from the frons: the hindwing venation, so far as known, is very distinct from that of all other families. There are two well-marked subfamilies, the Melyrinae without exsertile vesicles on the abdomen, and the Malachiinae with such vesicles. The former are represented in both countries by the genus *Dasytes*; the New Zealand *D. anacharis* Broun (fig. R44) is greenish black, 5 mm. long. The Malachiinae, absent from New Zealand, are abundantly represented in Australia, chiefly by species of *Laius*, *Carphurus*, *Helcogaster* and *Balanophorus*. In *Laius* the males have the pedicel of the antennae small and concealed in the greatly inflated or distorted third segment; the other three genera have short elytra and the males possess a comb on the first segment of each fore tarsus; in *Balanophorus* the female also has these combs, and the males have flabellate antennae.

Family 39. **Cleridae** [Aus. 299, N.Z. 30]. Tarsi 5-5-5 or 4-4-4, the hind tarsus sometimes with first segment very short above, obliquely united with the second; segs. 2-4 usually prolonged into flaps below, and one or more of them bilobed; clypeus distinct; labial palpi often longer than maxillary palpi, the distal segment generally hatchet-shaped; antennae serrate, flabellate or clubbed; hind coxae transversely placed, deeply sunk, covered by the hind femora; elytra not so soft as in Lampyridae; abdomen with 5-6 visible sternites, all movable. Larvae active, cylindrical, with well-developed legs; mostly predaceous or parasitic on other insects or their larvae.

These very handsome beetles are mostly predaceous, but a large number of the Australian species are found visiting flowers. Most of the New Zealand species are small, the largest being *Balcus niger* Sharp, half-an-inch long; the commonest New Zealand genus is *Phymatophaea*, containing small but rather prettily marked species. Australia possesses many beautiful and graceful forms, the finest being the numerous species of *Lemidia*. The red and black *L. hilaris* Newm., 5 mm. long, is common on dead eucalyptus leaves; *L. mastersi* Lea is beautifully marked and has a very large head and eyes. The genera *Phlogistus* and *Eleale* also contain pretty species. *Allelidea* contains species with short elytra. *Tarsostenus* contains small, slender species which prey upon gall-forming Coccids. The largest Australian species are the very distinctively marked *Trogodendron fasciculatum* Schreib. (pl. 18, fig. 7), up to 15 mm. long, and the huge, dull brown *Natalis titana* Thoms., more than an inch long; both of these bite most viciously. Two common introduced species in both countries are the world-wide "ham beetle," *Necrobia ruficollis* Fabr., and the allied *N. ruficeps* de Geer, also found in carrion.

Family 40. **Lymexylidae*** [Aus. 9, N.Z. 0]. Antennae short, broad, mostly serrate; maxillary palpi abnormally developed, drooping and flabellate in the males; fore and middle coxae elongate cylindrical, the latter contiguous; hind coxae oblique, prolonged inwardly; tibiae without spurs; tarsi 5-5-5, very slender, longer than tibiae, filiform; abdomen with 5-7 visible sternites, all movable. Larvae wood-borers, elongate, with short legs. Few species of these long and slender beetles are known, and most of them are rare. *Lymexylon* and *Hylecoetus* contain species in which the elytra completely cover the body; one of the best known Australian species is *H. pervagus* Oll. (pl. 18, fig. 8) dark brown in colour. *Atractocera* contains even slenderer species with very short elytra but large hindwings; these insects have been seen in Western Australia flying in swarms around bushes at dusk, rising and falling in the air like May-flies.

*Genus *Lymexylon* from Greek *lume* injury and *xulon* wood, stem *xyl-*, hence Lymexylidae, not Lymexylonidae.

Superfamily XIII. DASCILLOIDEA.

In this group are included three families which show relationships with the Lampyroidea on the one hand (through the Melyridae) and with the Elateroidea on the other (through the Dryopidae). These connections are in each case with the Dascillidae, the other two families being more specialized. The beetles comprised in this group are of variable shape; their integument and elytra are usually hard, though somewhat flimsy in many Dascillidae; antennae very variable in form; fore coxal cavities always open behind; tarsi 5-5-5; venation of hind-wing of the Lampyroid type. The three families may be distinguished as follows:—

1. Head free, not retractile beneath prothorax. 2
   Head not free, usually retracted beneath prothorax, or, if not, then small and closely affixed to it. Fam. 43. PTINIDAE
2. Tarsi with a bristly process (onychium) between claws; antennae of male flabellate, often with a large number of segments. Fam. 42. RHIPIDOCERIDAE
   Tarsi without onychium; antennae rarely flabellate, usually filiform or serrate, never with more than 11 segments. Fam. 41. DASCILLIDAE

Family 41. **Dascillidae** [Aus. 34, N.Z. 121]. Small to medium-sized beetles of somewhat fragile, delicate build, with flimsy integument and more or less oval form; hind coxae transversely placed; abdomen with five visible sternites, all movable. Larvae more or less broad and flattened, often with

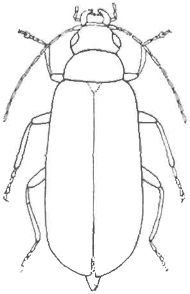


FIG. R45. *Veronatus longipalpis* Sharp, New Zealand, fam. Dascillidae. Length 10 mm. [*A. Tonnoir del.*

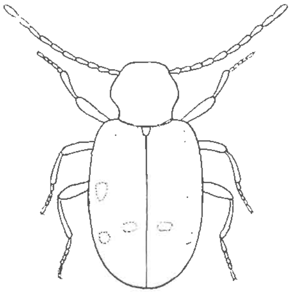


FIG. R46. *Ptinus exulans* Macl., Australia, fam. Ptinidae, subfam. Ptininae. Length 2.8 mm. [*A. Tonnoir del.*

lateral processes; terrestrial or aquatic. New Zealand appears to be the headquarters of this family; the principal genera are *Cyphon, Nesocyphon, Cyphanus* and *Veronatus*. *V. longipalpis* Sharp (fig. R45), one of the largest species, is 10 mm. long, dark chestnut shading to blackish. *Byrrhodes gravidus* Sharp, 9 mm. long, is a much more convex and broadly oval, dark chestnut-coloured beetle. The best known of the Australian genera is *Macrohelodes*, containing species resembling lady-birds, even exuding a yellow oil from their joints as the latter do. Undetermined larvae belonging to this family are found commonly clinging to rocks in running streams, particularly in Tasmania; they are of a broad, flattened form, superficially resembling small Trilobites.

Family 42. **Rhipidoceridae*** (Feather-horned Beetles) [Aus. 13, N.Z. 0]. A small family of elongate beetles of moderate size and handsome appearance; tarsi furnished with a bristly process or onychium between the claws; antennae of males flabellate, often with much more than eleven segments, of

*Greek *rhipis* a fan, stem *rhipid-* (not *rhips* a mat, stem *rhip-*), hence Rhipidocera, not Rhipicera.

the females serrate: mandibles large, strongly curved; fore and middle coxae subconical, prominent; abdomen with five visible sternites, rarely six. Larvae elongate, cylindrical, with short legs. The best known of the Australian species is *Rhipidocera femoralis* Kby. (pl. 18, fig. 5); the wonderful antennae of the male contain about forty-eight distinct segments. The largest species is *Rh. tesselata* Wwd.

Family 43. **Ptinidae** [Aus. 166. N.Z. 36]. A very distinct and somewhat isolated family, recognized by the form of the head, which is always either retracted beneath the prothorax, or, if visible, small and closely affixed to it; prosternum short; fore and middle coxae contiguous or nearly so; hind coxae transversely placed, not dilated; antennae variable; abdomen with five visible sternites. Larvae somewhat resembling those of the Scarabaeoidea (fig. R11), but with shorter legs; wood-borers or feeders on dried animal matter.

There are two very distinct subfamilies. The Anobiinae are borers and have the antennae inserted on the anterior margin of the eyes; they are shortly cylindrical, oval or almost globular in form, and some of them can contract their legs and head almost as completely as do the Byrrhidae. They are abundant in both countries, the principal genus being *Anobium*. Amongst introduced species are the three world-wide pests *Anobium punctatum* de Geer (=*domesticum* Geof., =*striatum* Ol.) the common furniture borer or "greater death-watch", which does great damage to wooden houses and furniture, *Sitodrepa panicea* Fabr., the "drug-store beetle", also known as the "biscuit weevil", and *Lasioderma serricorne* Fabr., the "cigarette beetle", which damages tobacco.

The Ptininae are not borers, and have the antennae inserted on the frons; the head and prothorax are much narrower than the abdomen, there being always a marked constriction between pronotum and elytra. Many of the species are of remarkable shape and sculpture. The genus *Ptinus* contains some beautiful little species in both countries; the Australian *P. exulans* Macl. (fig. R46) is dark brown with white spots on elytra and scutellum; *P. eminens* Oll. has been reared from large Coccidae in Australia. A number of very remarkable genera are found in ants' nests in Australia. Of these, *Enasiba*, *Diplocotes* and *Diphobia* have stout, 11-segmented, more or less moniliform antennae, those of the first-named with irregularly-shaped segments; *E. tristis* Oll. (pl. 16, fig. 12), 4-5 mm., blackish, is the best-known species. *Paussoptinus laticornis* Lea (pl. 16, fig. 14) has the antennae flattened into a lamina somewhat like those of Paussidae. *Hexaplocotes sulcifrons* Lea (pl. 16, fig. 13) has 6-segmented antennae ending in a huge, capitate club of two segments; *Ectrephes kingi* Wwd., *E. pascoei* Wwd., and *E. formicarum* Pasc. (pl. 16, fig. 15) have the antennae reduced to two segments, the distal one elongate and flattened. These genera are amongst the most extraordinary of all inquilines; their principal hosts are various species of *Iridomyrmex*.

Superfamily XIV. ELATEROIDEA (STERNOXIA).

This group includes those families in which the prosternum has a posterior process which fits into a cavity of the mesosternum. They are all more or less elongate in form (the Dryopidae less so than the others) and have a tough cuticle and hard elytra which entirely cover the abdomen. In the Dryopidae, the development of the prosternal process is somewhat variable, being weak in some genera but in others quite as strong as in the Buprestidae; these two families are also closely related by the remarkable character of the antennary pores, the Buprestid subfamily Julodinae (absent from our region) having them diffused and pubescent exactly as in Dryopidae. This latter family, however, might with almost equal reason be placed in the previous superfamily, next to the Dascyllidae, and must be regarded in some measure as an annectent group. The remaining families are more closely united, having in every case the fore and middle coxae globular. Antennae variable, rarely clubbed (only in *Throscus* and a few Parnidae); tarsi always 5-5-5; except in Dryopidae and some Cebrionidae, the posterior coxae are hollowed out to receive the femora, as in Byrrhoidea. The venation of the hind-wing is fairly close to the Lampyroid type. Six families can be recognized altogether, distinguished as follows:—

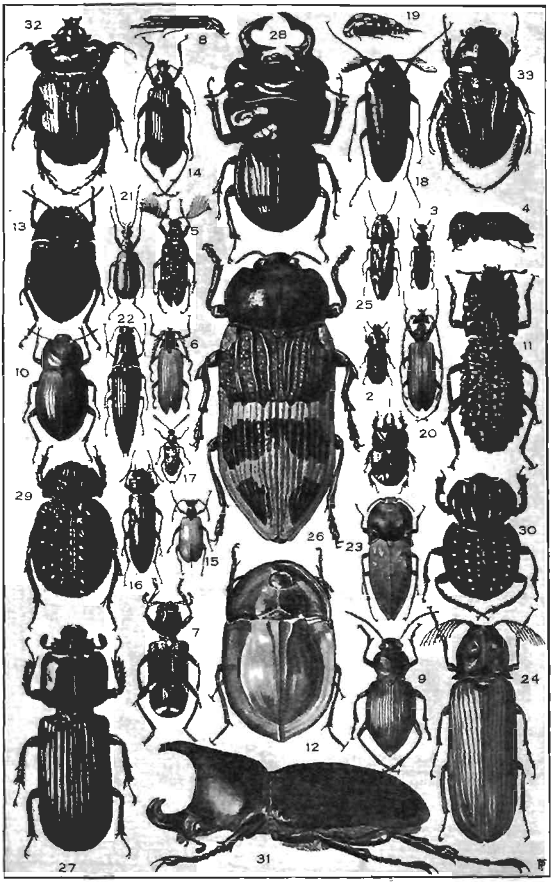
1. Small, aquatic or semi-aquatic beetles; tarsal claws very large. — Fam. 44. DRYOPIDAE
   Not such beetles. — 2
2. Prothorax firmly fixed to pterothorax; prosternal process flat, immobile. — 3
   Prothorax loosely attached to pterothorax; prosternal process not flat, usually more or less freely mobile within a cavity of the mesosternum. — 4

Plate 18

COLEOPTERA (Clavicornia to Lamellicornia)

All figures natural size, except fig. 17

1. *Hololepta sidnensis* Mars. (Fam. Histeridae).
2. *Leperina nigrosparsa* Wh. (Fam. Trogositidae), N.Z.
3. *Deretaphrus ignarius* Pasc. (Fam. Colydiidae).
4. *Bostrychopsis jesuita* Fabr. (Fam. Bostrychidae).
5. *Rhipidocera femoralis* Kby. (Fam. Rhipidoceridae).
6. *Metriorrhynchus rhipidius* W.S.M. (Fam. Lampyridae).
7. *Trogodendron fasciculatum* Schreib. (Fam. Cleridae).
8. *Hylecoetus pervagus* Oll. (Fam. Lymexylidae).
9. *Adelium striatum* Pasc. (Fam. Tenebrionidae).
10. *Cilibe opacula* Bates (Fam. Tenebrionidae), N.Z.
11. *Zopherosis georgei* Wh. (Fam. Tenebrionidae).
12. *Helaeus brevicostatus* Blkb. (Fam. Tenebrionidae).
13. *Saragus incisus* Pasc. (Fam. Tenebrionidae).
14. *Tanychilus splendens* Bless. (Fam. Cistelidae).
15. *Lagria grandis* Gyll. (Fam. Lagriidae).
16. *Chalcodrya variegata* Redt. (Fam. Melandryidae), N.Z.
17. *Lemodes coccinea* Boh. (Fam. Anthicidae), (x 1.3).
18. *Pelecotomoides conicollis* Cast. (Fam. Rhipiphoridae).
19. *Mordella leucosticta* Germ. (Fam. Mordellidae).
20. *Palaestra rubripennis* Cast. (Fam. Cantharidae).
21. *Zonitis tricolor* Le Guil. (Fam. Cantharidae).
22. *Metablax acutipennis* Wh. (Fam. Elateridae), N.Z.
23. *Psorochroa granulata* Broun (Fam. Elateridae), N.Z.
24. *Tetralobus corrosus* Cand. (Fam. Elateridae).
25. *Ophidius histrio* Bd. (Fam. Elateridae).
26. *Stigmodera tibialis* Waterh. (Fam. Buprestidae).
27. *Aulacocyclus teres* Perch (Fam. Passalidae).
28. *Lissotes acmenus* Lewis (Fam. Lucanidae), male, N.Z.
29. *Megalotrox dohrni* Har. (Fam. Trogidae).
30. *Aulacopris reichei* Wh. (Fam. Scarabaeidae).
31. *Xylotrupes australicus* Thoms. (Fam. Scarabaeidae).
32. *Pseudoryctes trifidus* Blkb. (Fam. Scarabaeidae).
33. *Trichaulax phillipsi* Schreib. (Fam. Scarabaeidae).



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COLEOPTERA (Clavicornia to Lamellicornia)

3. Head vertical, concealed beneath prothorax; antennae without visible pores. Fam. 46. THROSCIDAE
Head only partially concealed beneath prothorax (as far as posterior margin of eyes); antennae with visible pores. Fam. 45. BUPRESTIDAE
4. Tibiae dilated, formed for digging, with strong spurs. Fam. 49. CEBRIONIDAE
Tibiae slender, not formed for digging; spurs weak or absent. 5
5. Labrum free, visible; antennae inserted close to eyes. Fam. 48. ELATERIDAE
Labrum hidden; antennae inserted on the frons, not so close to eyes. Fam. 47. EUCNEMIDAE

Family 44 **Dryopidae** (**Parnidae**) [Aus. 10, N.Z. 10]. Small, dull-coloured, aquatic or semi-aquatic beetles, head retractile, concealed beneath prothorax; antennae of variable form, with distinct pores covered with pubescence; tarsi 5-5-5, the fifth segment much longer than the others, the claws very strongly developed; process of prosternum sometimes narrow, sometimes broad and well developed; abdomen with five visible sternites (except in Psepheninae), of which two or more at the base are fused together. Larvae cylindrical, or broad and flattened.

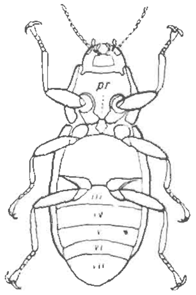


FIG. R47. *Helmis tasmanicus* Blkb., Tasmania, fam. Dryopidae, subfam. Helminae. Length 5 mm. Ventral view; *pr*, prosternal process; *iii-vii*, visible sternites. [*A. Tonnoir del.*

This small family comprises three distinct subfamilies, of which the Psepheninae are not recorded from Australia or New Zealand. The Dryopinae have the antennae with a large club formed of 7-9 segments, and recalling that of the Heteroceridae (fig. R31); their hind coxae are much enlarged; their larvae are slender and cylindrical, living in damp earth. The genus *Alloparnus* occurs in New Zealand. The Helminae have the antennae filiform or barely enlarged distally, the hind coxae narrow, and the larvae broad, flattened, more or less oval, aquatic. The genus *Hydora* occurs in New Zealand. *Helmis tasmanicus* Blkb. (fig. R47) is dull black with pale spots on elytra, and is found in Tasmania and in the alpine parts of Australia.

Family 45. **Buprestidae** (Jewel Beetles) [Aus. 766, N.Z. 2]. Beetles of more or less elongate form, with very solid cuticle and hard elytra; head retracted as far as hind margin of eyes; antennae short, serrate except very rarely, e.g. *Hypostigmodera variegata* Blkb. in which the male has flabellate antennae; prothorax closely fitted to pterothorax; hind angles of pronotum not projecting; prosternal process flat, immobile; tarsi 5-5-5, segs. 1-4 usually with pads beneath; abdomen with five visible sternites, the first usually long, closely united with the second, the others mobile. Larvae (fig. R48, C) elongate, fleshy grubs, with small head and very broad, flattened thorax, without legs: feeding on wood, mostly under the bark or in the roots of living trees and shrubs; some of them form galls.

Australia and Madagascar are the headquarters of this wonderful family, which contains the most beautiful of all beetles, rivalling in their brilliant colours and graceful shape anything to be found in the whole of the Class Insecta. Apart from two small species, *Nascioides enysi* Sharp and *Neocuris eremita* Wh., the family is absent from New Zealand, thus offering a close parallel to the natural order Proteaceae amongst plants, which are abundant in Australia but have only two species in New Zealand.

The classification of the family is founded principally upon the arrangement of the antennary pores, the size of the scutellum, the shape of the antennary grooves of the prothorax, etc.; on these characters, the Australian species fall into seven subfamilies.

The Agrilinae include a large number of small, mostly subcylindrical forms, having a fairly large scutellum and the tarsal claws toothed. The principal genera are *Ethon*, *Cisseis*, *Hypocisseis* and *Neospades*, with numerous prettily spotted species whose larvae are gall-formers. *Cisseis leucosticta* Kby., 12 mm.

long, with metallic bronze pronotum and black elytra speckled with white dots, is common on wattles (*Acacia*). *Hypocisseis latipennis* Macl. has two mirror-like areas on its head. The smallest of all Australian species belong to the genera *Germarica*, tiny gems found on she-oak (*Casuarina*), and to *Trachys* and *Aphanisticus*.

The Stigmoderinae, with fairly large scutellum but tarsal claws simple, are represented by the three fine genera *Stigmodera*, *Calodema* and *Metaxymorpha*,

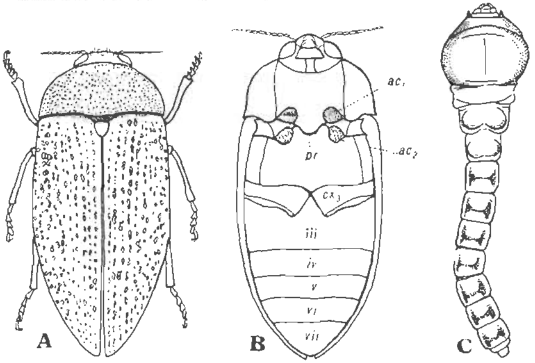


FIG. R48 (from left to right). A, *Stigmodera macularia* Don., Australia, fam. Buprestidae, subfam. Stigmoderinae. Length 27 mm. Dorsal view. B, ventral view of same, with legs removed; *ac*, coxal cavity; *cx*, coxa; *pr*, prosternal process; *iii-vii*, visible sternites. C, larva of *Stigmodera* sp. indet. Length 37 mm. [*A. Tonnoir del.*

and range in size from small to very large forms. The great genus *Stigmodera* is dominant throughout Australia, more than 300 species being known. The type of this genus is *S. macularia* Don. (fig. R48), a very common species found visiting the flowers of tea-tree (*Leptospermum*) and *Angophora* in Eastern Australia during November; it has a purplish-black head and pronotum, and the elytra are yellowish, deeply pitted all over with small, shiny black dots. The allied *S. jacquinoti* Bd. has the elytra ending in sharp spines. A group of slightly smaller but extremely beautiful species from Western Australia includes *S. gratiosa* Chev. and *S. roei* Hope, having the elytra of a dark metallic greenish colour, deeply pitted all over, the pits reflecting a bright metallic green, so that the whole beetle glows like a veritable jewel; in addition, *S. roei* Hope has three pairs of large orange spots. Both these species are used for mounting in brooches. *S. macfarlanei* Waterh., 30 mm. long, is a strikingly beautiful species from North-western Australia, with a brilliant, bronze pronotum and orange-yellow elytra crossed by two broad fasciae of purplish black; *S. saundersi* Waterh. is smaller, with reddish elytra crossed by two black fasciae; *S. suturalis* Don. (pl. 15, fig. 12) is purple with orange elytra; *S. pascoei* Saund., 25 mm. long, has red pronotum and rich yellow elytra with the apical third black with a reddish sheen. Amongst the giants of the group, measuring up to two inches in length or more, are *S. grandis* Don., from New South Wales, black with reddish edges to pronotum and elytra, the somewhat similar but larger *S. gigas* Cart. from Western Australia, *S. heros* Géhin, from Queensland, uniformly dark red, and *S. tibialis* Waterh. (pl. 18, fig. 26) from South Australia, with black pronotum and yellowish elytra heavily marked with blood-red blotches. Amongst the many small species remarkable for their beauty, we can only mention *S. ocelligera* Gory, 10 mm. long, green, with the apices of the elytra yellow enclosing a round black spot, *S. cyanicollis* Bd. (pl. 15, fig. 13), orange and green, and *S. nasuta* Saund., a rather slender, red species with black thorax and narrow, prominent head, clearly a mimic of the genus *Metriorrhynchus* (p. 213). Most of

the species are very constant in colouring, but the very common *S. variabilis* Don., about an inch long, found on *Angophora* blossom, is one of the most variable of all Australian beetles, the elytra being yellow or orange, ranging from the pure, unspotted colour to forms heavily barred with varying patterns of black. The genus *Metaxymorpha* contains some very handsome species an inch or more in length, the finest being *M. gloriosa* Blkb. and *M. grayi* Parry. *Calodema regalis* L. & G. (pl. 15, fig. 14) is by many considered the most beautiful of all Australian beetles; *C. plebeja* Jord. (pl. 15, fig. 15) is also very handsome.

The Polycestinae and Chrysobothrinae are smaller groups, the best known genera in the former being *Xyroscelis* and *Julodimorpha*, in the latter *Chrysobothris*. The Buprestinae are represented by a large number of genera of small to medium-sized species, mostly somewhat flattened in shape, and with a small scutellum. *Astraeus* is a genus of convex, oval form, with spotted or fasciate elytra, mostly found on she-oak (*Casuarina*), and well represented in Western Australia. *Nascio* and *Nascioides* contain finely sculptured species of various colours. *Nascio vetusta* Bd., 17 mm. long, has a strongly ridged pronotum and brown elytra with large blackish blotches, and looks as though it were carved out of wood. The large genus *Melobasis*, with nearly 70 species, contains brilliantly metallic forms chiefly associated with wattles (*Acacia*); *M. gratiosissima* Thoms. (pl. 15, fig. 10), *M. purpurascens* Fabr., *M. superba* L. & G. and *M. nobilitata* Thoms. have fasciate elytra; *M. nervosa* Bd. is bronze with raised lines on the elytra; *M. metallifera* Hope (pl. 15, fig. 11) and *M. cuprifera* L.

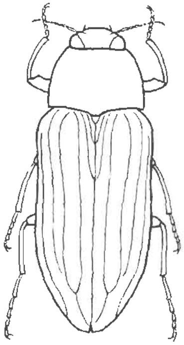


FIG. R49. *Merimna atrata* C. et G., Australia, fam. Buprestidae, subfam. Buprestinae. Length 24 mm. [*R. J. T. del.*

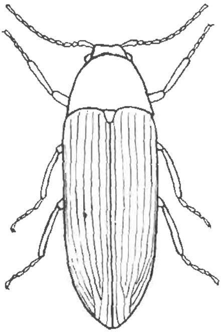


FIG. R50. *Lycaon novus* Bon., Australia, fam. Eucnemidae. Length 9 mm. [*A. Tonnoir del.*

& G. are entirely coppery. Other interesting genera are *Neocuris*, *Curis*, *Anilara* and *Merimna*. *M. atrata* L. & G. (fig. R49), is a flattened, dull black species about an inch long, commonly known as the "fire-beetle", from its habit of being attracted to the hot ashes of bush or camp fires; it also comes to light.

All the above groups agree in having the antennary pores concentrated in a small depression on each segment. In the two following subfamilies, the pores occupy both faces of each segment.

The Chalcophorinae have the scutellum distinct. Seven genera occur in Australia, one of the most distinctive being *Diadoxus*, the species of which are attached to native and introduced pines. The other six genera form a group of closely associated forms, mostly tropical, with metallic colouring, strongly sculptured elytra and having marked grooves or depressions on the pronotum; the principal genera are *Chalcotaenia* and *Pseudotaenia*, the latter containing very large species such as the metallic green *Ps. ajax* Saund., nearly 2 inches long, with a golden sheen. *Chrysodema aurofoveata* Guer. (pl. 15, fig. 17) is a rare

tropical species with rich golden depressions on the pronotum. *Paracupta albivittis* Hope, with beautiful gold or green lateral stripes on pronotum and elytra, ranges from South Queensland to Tasmania.

The Chrysochroinae are a small group which only differ from the above in not possessing a distinct scutellum. The only two Australian genera are *Cyria* and *Cyrioides*; the former are called "Banksia Beetles." *Cyria imperialis* Don. (pl. 15, fig. 16) is a handsome species found on native honeysuckle (*Banksia*).

Family 46. **Throscidae (Trixagidae)** [Aus. 2, N.Z. 0]. A small family, intermediate between the Buprestidae and Elateridae; resembling the former in the close connection between the prothorax and pterothorax, the flat prosternal process and the lack of the ability to skip; resembling the latter in the insertion of the antennae close to the eyes, and in the general appearance and dull coloration; differing from both in having the head vertical, retractile beneath the prothorax. The only known Australian species are *Aulacothroscus elongatus* Bonv., common in Eastern Australia and Tasmania, and *Lissomus* (*Drapetes*) *vicinus* Fleut.; the former has clubbed and the latter serrate antennae.

Family 47. **Eucnemidae** [Aus. 75, N.Z. 20]. Prothorax loosely attached to pterothorax; prosternal process compressed, movable within a cavity of the mesosternum, but without power to produce skipping; head vertical, partially retractile; antennae inserted on the frons, not so near eyes as in Throscidae and Elateridae; labrum hidden. Larvae resembling those of *Buprestidae*. The species are of dull colouration, resembling Elaterids, and are nearly all rare. *Lycaon novus* Bon. (fig. R50), the best known of the Australian species, is 8 mm. long, with blackish pronotum and brown elytra. *Gallio australiae* Lea, the finest species, comes from North Queensland. *Neocharis* and *Talerax* are the chief genera in New Zealand.

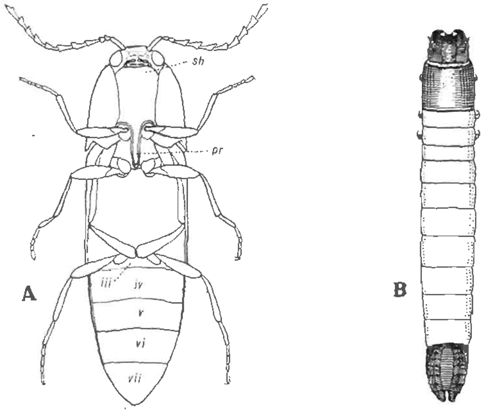


FIG. R51. A, *Thoramus wakefieldi* Sharp, New Zealand, fam. Elateridae, subfam. Elaterinae. Length 26 mm. Ventral view; *pr*, prosternal process; *sh*, shelf of prosternum; *iii-vii*, visible sternites. [*A. Tonnoir del.*]. B, larva of *Chrosis barbata* Cand., New Zealand, fam. Elateridae, subfam. Elaterinae. Dorsal view. Length 20 mm. [*R. J. T. del.*

Family 48. **Elateridae** (Click Beetles) [Aus. 364,* N.Z. 126]. Prothorax loosely joined to pterothorax; pronotum usually with hind angles prolonged into sharp processes; prosternal process more or less compressed,

*Mr. A. M. Lea's estimate is 472.

freely movable in a cavity of the mesosternum, and generally capable of producing the action of skipping; head depressed, rarely vertical; labrum free, visible; antennae inserted close to the eyes, 11-12 segmented, serrate, pectinate, flabellate or filiform; tibiae slender, spurs small or vestigial; tarsi often provided with flaps beneath, and ending in small claws; hind coxae transversely placed, hollowed out to receive the femora. Larvae (fig. R51, B) elongate, depressed or subcylindrical, with short legs, the segments armoured with hard plates, the last segment larger than the others and ending in a hard, truncated process; colour usually yellowish or orange brown, often very shiny; commonly known as "wire-worms". The beetles are mostly of dull coloration and elongate, more or less slender form; their vernacular name "click beetles" arises from the fact that, if held by the abdomen, most of the species can work their prothorax to and fro with a sharp clicking sound. This sound is produced by means of the prosternal process, which is notched at its apex; if the beetle is laid on its back, it draws its prothorax backwards so that the notch catches in the front edge of the mesosternal cavity like a taut spring; when this is let go, the process flies back into the cavity, and the force produced jerks the beetle up into the air and enables it to turn over.

The great majority of the Australian and the whole of the New Zealand species belong to the subfamily Elaterinae (fig. R51), dominant throughout the world; they have the prosternum forming a shelf in front and the mesosternum sloping. *Chrosis, Corymbites, Monocrepidius* and allied genera common to both countries include medium-sized, dull coloured species whose larvae are the common wire-worms found in gardens, where they do considerable damage by eating the roots of plants. The common large wire-worm of New Zealand (fig. R51, B) is the larva of the dull brown *Chrosis barbata* Cand.; a very common smaller wire-worm is the larva of a smaller and slenderer brown species, *Corymbites agriotoides* Sharp. *Protelater huttoni* Sharp is a slender New Zealand species, 12 mm. long, prettily marked. Other fine species found in New Zealand are the large *Thoramus wakefieldi* Sharp (fig. R51, A), the graceful, slender *Metablax acutipennis* Wh. (pl. 18, fig. 22), with sharply pointed elytra, and the peculiar *Psorochroa granulata* Broun (pl. 18, fig. 23), rather broad and flat, dull brownish, and remarkably sculptured. *Cryptohypnus* and *Lomemus* include a large number of species in New Zealand. Of the Australian forms, the genus *Crepidomenus* contains metallic species; *Cardiophorus* and *Anilicus* include a number of small but handsome species found on flowers; *Ophidius* contains the handsomest species of all, the elegant and beautifully patterned *O. histrio* Bd. (pl. 18, fig. 25), rich light brown with bizarre black markings, being the most striking species. In *Dicteniophorus* and *Agonischius* the males have flabellate antennae, and the same character occurs in the very large species of *Tetrigus* and *Tetralobus*; *Tetralobus corrosus* Cand. (pl. 18, fig. 24) is 40 mm. long, dull brown, while *Tetrigus australicus* Blkb. is somewhat smaller and slenderer, not so dark in colour.

Of the other subfamilies represented in Australia, the Hemirhipinae have the mesosternum horizontal, and are represented by the fine genus *Alaus*, large beetles curiously mottled with pale grey or whitish, so as to appear as if coated with lichens; the finest species is *A. gibboni* Newm., up to 2 inches in length and fairly broad in proportion. The Agrypninae are distinguished by having deep longitudinal grooves in the prosternum for reception of the antennae; they are represented by numerous species of the genus *Lacon* and by the larger species of *Agrypnus*. The Campylinae are a somewhat aberrant group differing from all the rest in not having the prosternum produced forwards into a shelf; the metasternum is sharply pointed in front; they are represented by the genus *Macromalocera*, in which the males have very long and slender antennae.

Family 49. **Cebrionidae**. [Aus. 1, N.Z. 0]. A small family closely allied to the preceding, but differing in the possession of dilated tibiae armed with strong spurs, formed for digging; antennae filiform; labrum free, broad; prosternum without an anterior shelf; prosternal process more or less enclosed in a mesosternal cavity, but without the power to produce skipping; in *Cebrio* the posterior coxae are not hollowed out to receive the femora. There is only one very rare Australian species, *Cebrio rubripennis* Guer.

Superfamily XV. TENEBRIONOIDEA (HETEROMERA).

The numerous families comprised in this group are all distinguished by possessing the tarsal formula 5-5-4; this character will at once suffice to separate the soft-bodied Oedemeridae and Cantharidae from the Lampyridae, which many of them

otherwise more or less closely resemble. Apart from the Monommatidae, which are perhaps a specialization from somewhere near the Throscidae, the other families form a fairly homogeneous group, all of which, except the Oedemeridae and Cantharidae, are very closely related to the dominant Tenebrionidae. The venation of the hindwing is very similar to that of the Lampyroidea, but the returning vein is usually shorter; a number of reduced and even wingless forms occur. There are twelve families represented in Australia; of these, the Monommatidae and Cantharidae are absent from New Zealand. The following Key will distinguish the families:—

1.	Cuticle and elytra soft, feebly chitinized.	2
	Cuticle and elytra hard, strongly chitinized.	3
2.	Head without a neck; tarsal claws simple.	Fam. 60. OEDEMERIDAE
	Head with a neck; tarsal claws with a long appendage beneath each.*	Fam. 61. CANTHARIDAE
3.	Claws pectinate.	Fam. 51. CISTELIDAE
	Claws smooth, simple.	4
4	Small, oval beetles.	Fam. 57. MONOMMATIDAE
	Not such beetles.	5
5	Head without a neck.	6
	Head with a neck.	11
6	Strongly curved, dorsally convex beetles, with the head capable of being deflected so as to cover the prosternum beneath.	7
	Not such beetles.	8
7	Sides of prothorax forming a sharp ridge; antennae filiform or slightly serrate.	Fam. 59. MORDELLIDAE
	Sides of prothorax not forming a sharp ridge; antennae flabellate in males, serrate in females.	Fam. 58. RHIPIDOPHORIDAE
8.	Fore coxal cavities closed.	9
	Fore coxal cavities open.	10
9.	Fore coxae globular, never contiguous; tarsal segments nearly always without lobes.†	Fam. 50. TENEBRIONIDAE
	Fore coxae prominent, conical, contiguous or nearly so; penultimate tarsal segment broader than the others, lobed, pubescent beneath.	Fam. 52. LAGRIIDAE
10.	Prothorax broad behind.	Fam. 53. MELANDRYIDAE
	Prothorax narrow behind.	Fam. 54. PYTHIDAE
11	Eyes coarsely granulated.	Fam. 55. ANTHICIDAE
	Eyes finely granulated.	Fam. 56. PEDILIDAE

Family 50. **Tenebrionidae** [Aus. 1078, N.Z. 152]. Antennae variable, (never pectinate or flabellate), inserted either above or below the level of upper margin of mandibles, and having the third segment usually elongated. Coxae separated; fore coxal cavities closed behind, the fore coxae short, not projecting; hind coxae separated by an intercostal process from the basal visible abdominal sternite, of variable shape; tarsi with penultimate segment nearly always without lobes or flaps; tarsal claws simple; abdomen with five visible sternites, of which the fourth is the shortest. Larvae elongate, subcylindrical, the segments provided with hard plates above and below, the legs well developed; thoracic spiracles placed well forward on mesothorax; feeders on rotten wood, bark, fungi, vegetable débris, etc.

This enormous family contains beetles of very variable size and shape, the great majority being found either on the ground, under logs and stones, or under the bark of trees. By no means all of them are of the dark colour which the family name suggests. Many of the ground-living forms are without hindwings. No less than twenty-seven subfamilies are represented in Australia, many of them being absent from New Zealand. Their classification is difficult, and we can only mention the more important of them here.

The Zophosinae are a primitive group represented in Australia by the very peculiar genus *Zopherosis*. The Ironbark Beetle, *Z. georgei* Wh. (pl. 18, fig. 11) is a long, subrectangular species, dull black and heavily sculptured; it is usually found on tree-trunks or under bark. The peculiar Dacoderinae are also represented by a single genus, *Tretothorax*, containing the single species *T. cleistostoma*

*Absent in a few non-Australian genera.
†Penultimate segment lobed in a few Helaeinae.

Lea (pl. 16, fig. 18), a small insect found in ants' nests in Queensland, and placed by Mr. A. M. Lea in a distinct family Tretothoracidae; in spite of a superficial resemblance to the Rhysodidae, the venation of the hindwing and the characters of the coxae and tarsi show that this is a true Tenebrionid.

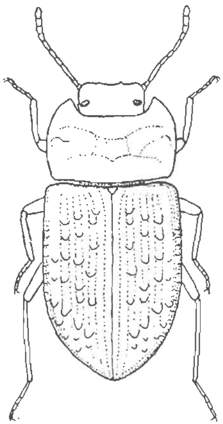


FIG. R52. *Syrphaetodes tuberculicostatus* Wh., New Zealand, fam. Tenebrionidae, subfam. Opatrinae. Length 13 mm. [*R. J. T. del.*

The Pedininae and Opatrinae are closely allied groups represented in both countries; the genus *Syrphaetodes* (fig. R52) contains numerous New Zealand species up to 12 mm. long, brown and prettily sculptured. The Bolitophaginae, Ulodinae and Diaperinae are related groups also represented in both countries; most of the New Zealand species belong to *Menimus* (Diaperinae). In the Ulodinae, the Australian genera *Ulodes, Byrsax, Dipsaconia, Mychestes* and allies are a group of interesting fungus-feeders; in the Diaperine genus *Platydema*, the males of some species have the heads curiously armed. The Ulominae and Tenebrioninae are represented by numerous genera in Australia and a few in New Zealand; *Uloma* (*Achthosus*) *westwoodi* Pasc. is a fine Australian species resembling a stag-beetle. The genus *Palorus* (Ulominae) contains some species which are pests of wheat; but the somewhat anomalous *P. eutermiphilus* Lea (pl. 16, fig. 17) lives in the nests of white-ants of the genus *Eutermes*. The Tenebrionine genus *Toxicum* contains Australian species with the heads of the males armed with horns, very variable in size and shape.

The Nyctozoilinae connect the Tenebrioninae with the Helaeinae and are well represented in both countries. Numerous species of *Cilibe* occur in New Zealand, *C. opacula* Bates (pl. 18, fig. 10) being one of the largest and commonest. In Australia the principal genera are *Nyctozoilus, Onosterrhus* and *Dysarchus*. All these beetles have distinct flanges to the pronotum. The Helaeinae are a very remarkable group known only from Australia and New Guinea, with wide flanges to the pronotum and elytra; the principal genera are *Helaeus, Pterohelaeus, Saragus* and *Encara*; the first two are known as "pie-dish" or "verandah" beetles; the general appearance is well illustrated by *Helaeus brevicostatus* Blkb. (pl. 18, fig. 12) and *Saragus incisus* Pasc. (pl. 18, fig. 13). In *Helaeus* the hindwings are absent, but *Pterohelaeus* has them well developed. *Sympetes macleayi* Pasc. is over an inch long, dark brown, with the flanges so wide that it appears almost circular in outline. In some species of *Helaeus* the flanges of the pronotum meet in front of the head. *Encara floccosa* Pasc. is an extraordinary species found crawling or resting on trees and fences; it is covered by a whitish, lichenous growth which affords it a high degree of protection from its enemies. This subfamily contains nearly 200 Australian species, found chiefly on the ground, under logs and stones; but *Pterohelaeus* occurs under bark.

The Adeliinae are well represented in both countries, the principal Australian genera being *Adelium* and *Cardiothorax*, while in New Zealand the allied genus *Pheloneis* is very abundant, closely resembling *Adelium*. *Ph. multistriatus* Sharp, 10 mm. long, dark brown, is one of the commonest species. The species of *Adelium* protrude a pair of eversible oil-glands when alarmed, giving out a strong odour; many of them can also stridulate. *Adelium striatum* Pasc. (pl. 18, fig. 9) is one of the largest and commonest species; some of the smaller species are bronze-brown and prettily sculptured. The species of *Cardiothorax* are of handsome form, with the pronotum more or less heart-shaped; they occur under logs in Eastern Australia only, from Cape York to Victoria, *C. acutangulus* Bates (pl. 16, fig. 16), *C. macleayi* Pasc. and *C. foveatus* Cart. are all fine examples; the first-named has been found in ants' nests (A. M. Lea). *Blepegenes aruspex* Pasc., a dull coppery beetle about an inch long, has a strongly armed head and prothorax. *Ectyche* and *Micrectyche* are two Western Australian genera belonging to the subfamily Amphidorinae.

The Cyphaleinae are an Australian group containing brilliantly metallic, actively flying species belonging to the genera *Cyphaleus, Platyphanes, Prophanes* and allies. *Prophanes mastersi* Pasc. (pl. 15, fig. 7) is a handsome species with peacock-blue colouring.

The Amarygminae are the largest group of Australian Tenebrionids, of strongly convex shape, brilliant metallic colouring, and emitting an unpleasant odour when alarmed; they are always found under bark, sometimes in large clusters of striking beauty. The principal genera are *Amarygmus* and *Chalcopterus*, the former with 55, the latter with 112 species. *C. nigritarsis* Pasc. and *C. variabilis* Blessig are common species. *Amarygmus zelandicus* Bates is the only New Zealand species of this group.

The larvae of six introduced, world-wide species are serious pests in flour, meal and other grain products; these are *Tenebrio molitor* L. (Yellow Mealworm), *T. obscurus* Fabr. (Dark Mealworm), *Tribolium ferrugineum* Fabr. (Flour Beetle), *Gnathocerus cornutus* Fabr., *Alphitobius diaperinus* Panzer and *A. laevigatus* Fabr.

Family 51. **Cistelidae** [Aus. 162, N.Z. 10]. Closely allied to the preceding family, from which they differ only in having the tarsal claws pectinate and in the presence of flaps on the penultimate segment of all six tarsi (also on third segment of fore and middle tarsi in all our species); the form is generally more slender and the integument somewhat softer than in Tenebrionidae.

Amongst a host of obscure brown or black forms the Australian genus *Aethyssius* stands out with brilliantly metallic colouring; *Ae. viridis* Bd. (pl. 15, fig. 8) is a handsome, bright green species. The fragile species of *Chromomoeca* and *Apellatus* are fairly numerous in Australia; some of them are prettily striped. One of the largest Australian species is the shining black *Tanychilus splendens* Blessig (pl. 18, fig. 14) with a somewhat triangular pronotum. The principal New Zealand genera are *Amarosoma, Xylochus* and *Omedes; O. fuscatus* Broun is a common, dull fuscous species, 6 mm. long.

Family 52. **Lagriidae** [Aus. 21, N.Z. 1]. A small family of dull-coloured beetles which differ from the Tenebrionidae only in having the penultimate segment of the tarsi lobed and pubescent beneath and from the Cistelidae in having the tarsal claws simple. Fore coxae prominent, conical, contiguous or nearly so, their cavities closed behind; abdomen with five visible sternites, all free. Most of the Australian species belong to the world-wide genus *Lagria*, found on low shrubs; *L. grandis* Gyll. (pl. 18, fig. 15), with bright brownish elytra, is one of the commonest. *L. formicicola* Lea is exceptional in occurring in ants' nests. *Lagrioida brouni* Pasc. is the only New Zealand species.

Family 53. **Melandryidae** [Aus. 60, N.Z. 41]. This family differs from the two preceding in having the cavities of the fore coxae open behind, the head depressed, more or less hidden, and the prothorax as wide basally as the elytra. Tarsi with penultimate segment often slightly bilobed, the claws nearly always simple. *Chalcodrya* contains the two fine New Zealand species *Ch. variegata* Redt. (pl. 18, fig. 16), speckled brownish in colour, and the smaller *Ch. mollis* Broun, 12 mm. long, speckled olive-greenish; other genera of importance in New Zealand are *Hylobia* and *Cteniplectron*. *Mystes planatus* Champ. is one of the most peculiar of the Australian species.

Family 54. **Pythidae** [Aus. 24, N.Z. 21]. Beetles of small size, only distinguished from the previous family by the prothorax being narrowed behind. *Salpingus* is the best known genus. *S. bilunatus* Pasc. (fig. R53) is a New Zealand species, brownish, with blackish markings on pronotum and elytra, and tips of antennae black; the larger *S. unguiculus* Broun is 5 mm. long, very dark, shiny brown.

Family 55. **Anthicidae** [Aus. 119, N.Z. 20]. Small, mostly slender and ant-like species with a distinct neck; prothorax narrow behind; eyes coarsely granulated; cavities of fore coxae widely open behind; hind coxae separated by a definite intercostal process as in Tenebrionidae; abdomen with five visible sternites. Most of the species belong to world-wide genera and are of graceful form. Many small, ant-like species belong to the genera *Anthicus* and *Formicomus* (the latter absent from New Zealand). *Trichananca* and *Lemodes** are peculiar to Australia; the latter contains very beautiful species, usually velvety red in colour, some-

*This genus was previously placed in the family Pyrochroidae, not otherwise represented in our region, and distinguished from the Anthicidae only by the very slightly separated hind coxae, and by the males having six visible sternites.

times marked with blue. *L. coccinea* Boh. (pl. 18, fig. 17). 6 mm. long, velvety red, has the black antennae tipped with white; it is common under logs in coastal scrubs of Eastern Australia. *Mecynotarsus albellus* Pasc. (fig. R55) from Western Australia, is a representative of a widespread genus having the pronotum forming a rugose hood covering the head from above; it is 2.5 mm. long and covered with a whitish pubescence. The principal genus in New Zealand is *Cotes*; *C. punctata* Broun (fig. R54) is an ant-like species 3 mm. long, brown, with elytra patterned in pale brown and blackish.

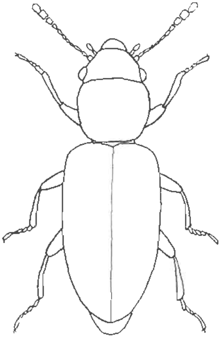


FIG. R53. *Salpingus bilunatus* Pasc., New Zealand, fam. Pythidae. Length 2 mm. [*A. Tonnoir del.*

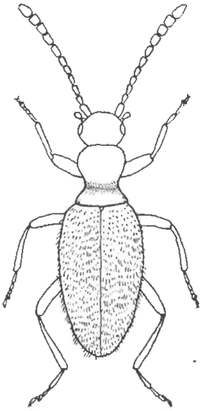


FIG. R54. *Cotes punctata* Broun, New Zealand, fam. Anthicidae. Length 3 mm. [*A. Tonnoir del.*

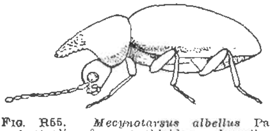


FIG. R55. *Mecynotarsus albellus* Pasc., Australia, fam. Anthicidae. Length 2.5 mm. [*A. Tonnoir del.*

Family 56. **Pedilidae** [Aus. 102, N.Z. 8]. Small beetles distinguished from the Anthicidae by their finely granulated eyes and contiguous hind coxae; abdomen with 5-6 visible sternites. Many of the genera are of highly specialized form and show considerable sexual dimorphism. *Xylophilus* is a remarkable Australian genus in which the males use their antennae as clasping organs. The widespread genus *Macratria* occurs in New Zealand.

Family 57. **Monommatidae**† [Aus. 1, N.Z. 0]. Small, oval beetles with head sunk into prothorax up to eyes, and limbs retracted close to body in repose; hind coxae separated by a large intercoxal process; abdomen with five

†Greek *monos* single, and *omma* eye, gen *ommatos*, stem *ommat-*, hence Monommatidae, not Monommidae.

visible sternites, the first large. A single species of the world-wide genus *Monomma* has been recorded from Australia.

Family 58. **Rhipidophoridae*** [Aus. 46, N.Z. 4]. Beetles of somewhat peculiar shape, dorsally arched, with the pronotum depressed, the head short, vertical, fitting closely against the prothorax and resting against the fore coxae; antennae flabellate in males; legs long; fore coxae very prominent, contiguous, their cavities widely open behind; hind coxae transverse, contiguous, often expanded into large laminae; tibiae with spurs; tarsal claws variable; abdomen with five visible sternites. Larvae parasitic in wasps' nests. The genera *Emenadia* and *Pelecotomoides* contain the finest Australian species; *P. conicollis* Cast. (pl. 18, fig. 18) is a handsome, dull brownish species measuring up to an inch in length.

Family 59. **Mordellidae** (Pintail Beetles) [Aus. 127, N.Z. 11]. Small to medium-sized beetles of very peculiar shape, broad in front and tapering to a point behind; pronotum strongly deflexed, its sides sharply ridged, the head tucked away beneath it; abdomen frequently drawn out apically into a long, pointed process, ending well beyond the tips of the elytra; antennae filiform, or slightly serrate; mandibles with an internal membranous lamina. Larvae more or less cylindrical or slightly curved, with very short legs; probably predaceous or parasitic on other larvae. These beetles are mostly very active, with great powers of jumping and skipping; they are found on flowers, shrubs, etc., in sunshine. Most of the species belong to the world-wide genera *Mordella* and *Mordellistena*. *Mordella dumbrelli* Lea and *M. leucosticta* Germ. (pl. 18, fig. 19) are two of the finest Australian species: *M. tairuensis* Broun, 8 mm. long, is one of the largest found in New Zealand; all these are black or deep steely blue-black, with white or cream-coloured blotches. Numerous smaller and slenderer species in both countries belong to the genus *Mordellistena*.

Family 60. **Oedemeridae** [Aus. 101, N.Z. 36]. Slender, graceful insects with soft body and elytra, antennae and legs slender; many of the species have a close resemblance to Lampyridae, while others resemble Longicorns; the tarsal formula 5-5-4 will at once distinguish them. Head without a distinct neck; antennae nearly always filiform; prothorax narrower at base than elytra; all three pairs of coxae nearly always contiguous; cavities of fore coxae open behind; tarsi with penultimate segment usually bilobed; tarsal claws simple; abdomen with 5-6 visible sternites, all free. Larvae cylindrical with short legs;

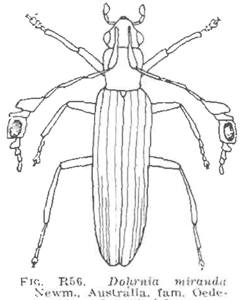


FIG. R56. *Dohrnia miranda* Newm., Australia, fam. Oedemeridae. Length 9.5 mm. [*A. Tonnoir del.*

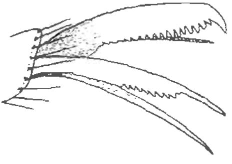


FIG. R57. *Palaestra rubripennis* Cast., Australia, fam. Cantharidae; claws of hind tarsus, showing pectinations and elongated processes (× 50). [*R. J. T. del.*

borers in decaying wood. Many of the Australian species belong to the genera *Copidita*, *Oxacis* and *Pseudolycus*, those of the last-named genus mimicking species of *Metriorrhynchus* (p. 212). The males of the Australian *Dohrnia miranda* Newm. (fig. R56) have extraordinary antennae. The finest species of all is *Agasma semicrudum* Newm. (pl. 15, fig. 9) found in the scrubs of northern N.S.W. and southern Queensland. The best known of the New Zealand genera are *Sessinia* and *Techmessa*; the former contains slender, pale straw-coloured species, of which

*See note at bottom of p. 214

S. lineata Fabr., 18 mm. long, is the largest; the latter genus contains smaller species, dark brown in colour.

Family 61. **Cantharidae** [*Aus. 79, N.Z. 0*]. Distinguished from the preceding family only by the presence of a distinct neck and by the tarsal claws being pectinate or simple, nearly always with a long, slender appendage beneath each of them (fig. R57). The best known Australian genera are *Palaestra* and *Zonitis*, both containing some handsome species; *P. rubripennis* Cast. (pl. 18, fig. 20), 18 mm. long, is shiny black with bright red elytra, its coloration resembling that of many species of *Metriorrhynchus* (p. 212); *Z. tricolor* Le Guil. (pl. 18, fig. 21), about 12 mm. long, is orange yellow with the posterior three-fifths of the elytra metallic greenish-black, while *Z. purpureipennis* Waterh. is entirely purple. *Goetymes* and *Sitarida* have curiously shortened elytra. The family is of special interest because the bodies of a number of the species contain a substance which raises blisters when applied to the human skin; hence the popular name of Blister Beetles. The larvae of some of the species undergo a remarkable hypermetamorphosis; the young larva is of an active, caraboid type and is known as a *triungulin*; this changes to a resting or "coarctate" larva, which, at the second instar, takes on the curved melolonthoid form; this again changes into the curculionoid or weevil type of legless grub. None of the life-histories of the Australian species are known, but the larvae should be searched for in the nests of native bees or wasps, and in the egg-masses of locusts or egg-capsules of cockroaches and Mantids.

Superfamily XVI. SCARABAEOIDEA (LAMELLICORNIA).

The principal character which marks this very distinct group lies in the antennae, which are short, with 7-11 segments, the last three or more being expanded, on the inner side only, in the form of lamellae; these lamellae together form an asymmetrical and more or less close-fitting club. A few Lucanidae lack this character or have it very feebly developed, but they can easily be recognized by other well-marked characters, such as the general facies and the development of the huge mandibles of the males. The antennae are often strongly bent, or even sharply elbowed, sometimes between the elongated scape and the rest, sometimes between the club and basal portion. Head small; prothorax always large; tarsi 5-5-5; males frequently specialized for fighting, either by the possession of huge mandibles, or by the development of horned processes on head or prothorax; wing-venation of a very distinct type, with returning vein and apertum, the veins very strong; the wing folding by a single pivot-fold hinging on the pterostigma. Larvae soft, curved, whitish grubs with well developed legs and large, specialized apical segments of the abdomen (melolonthoid type, fig. R11); feeding in rotten wood, or on roots, vegetable matter, dung, etc. The origin of the group is uncertain but the form of the antennae and the venation appear to point to a considerable amount of affinity with the Trogositidae. Four families are here recognized as follows:—

1. Elytra entirely covering the abdomen, which has only five visible sternites. 2
   Elytra nearly always leaving pygidium uncovered; abdomen with six visible sternites and an extra segment visible laterally. *Fam. 65.* SCARABAEIDAE
2. Antennae with the lamellate segments fixed, not capable of being closely co-adapted with one another to form a solid club. 3
   Antennae with the lamellate segments mobile, capable of being closely coadapted with one another to form a solid club. Fam. 64. TROGIDAE
3. Labrum large, mobile; submentum deeply excised in middle; antennae curled up in repose. Fam. 62. PASSALIDAE
   Labrum indistinct, immobile, submentum not excised; antennae not curled up in repose Fam. 63. LUCANIDAE

Family 62. **Passalidae** [Aus. 39, N.Z. 0]. Large, black or dark brown beetles with little difference between the sexes; pronotum and elytra of equal width, the latter parallel-sided; antennae with bent, 3-segmented, lamellate club, curled up in repose; labrum large, mobile; labium with submentum excised medially; elytra entirely covering the abdomen, which has five visible sternites. Larvae and beetles both capable of stridulating loudly and both found in decaying logs, rotten wood, etc. The Australian species belong chiefly to the three genera *Aulacocyclus*, *Pharochilus* and *Episphaenoides* (*Mastochilus*). The commonest species are *Ph. dilatatus* Dalm., *Ph. politus* Burm., and *A. edentulus*

W.S.M.; *A. teres* Perch. (pl. 18, fig. 27) is rarer. *E. capitalis* Blkh. is the largest, measuring up to 2 inches in length.

Family 63. **Lucanidae** (Stag Beetles) [Aus. 68, N.Z. 36]. Moderate to large species, not as elongated as Passalidae; sides of elytra usually not parallel; antennae with the lamellate segments not fitting closely together, and often poorly developed (lamellae absent in some species of *Lissapterus*), not curled up in repose; labrum indistinct, not movable; labium with submentum not excised medially; elytra entirely covering abdomen, which has five visible sternites. Sexes very distinct, the males larger than the females, often having the mandibles greatly enlarged and sometimes prolonged forwards, suggesting the antlers of a stag. Larvae found in rotten wood, chiefly of large forest trees; the beetles are found in the same localities, often inside the wood too.

The New Zealand species belong to *Lissotes*, *Ceratognathus* and *Mitophyllus* (the first two genera also occurring in Australia and Tasmania). The largest species is *Lissotes acmenus* Lewis (pl. 18, fig. 28) in which the very variable male measures up to 40 mm. long, by 20 mm. wide, with enormous jaws; both sexes are shining black. The smaller *L. punctulatus* Wwd. is nicely marked in black and brown. *Mitophyllus parryanus* Hope is a rather handsome species speckled in black and brown, about half-an-inch long. Of the Tasmanian species of *Lissotes*, *L. obtusatus* Wwd., dull blackish, about 15 mm. long, is one of the best known. The finest Tasmanian stag-beetle is *Hoplogonus simsoni* Parry (fig. R58), a black species which is remarkable in having humeral spines on the elytra. *Lissapterus* contains black Eastern Australian species in which the males often have large forcipate mandibles, and the antennae have little or no development of lamellae. *Figulus regularis* Wwd., half-an-inch long, a shiny black species with short mandibles and striated elytra, occurs commonly under logs in Australia. *Eucarteria floralis* Lea, the smallest of all the Australian species, has the exceptional habit of visiting flowers; it occurs on the Dorrigo Plateau and Barrington Tops, N.S.W. *Rhyssonotus* and *Lamprima* are two fine genera peculiar to Australia. *Rh. nebulosus* Kby. measures up to 30 mm. long and is dull fuscous, with large prothorax, small head, antennae with the lamellae very short, and mandibles of remarkable shape in the male. The genus *Lamprima* contains the beautiful stag-beetles commonly known as "Gold Beetles" in Eastern Australia, found in numbers on the young foliage of Banksia and sometimes on Eucalyptus. *L. latreilli* W.S.M. (pl. 15, fig. 18) is common in Eastern Australia and Tasmania; the mandibles of the male have a cushion or pad of orange-brown hairs on the inner side. The bronze *L. micardi* Reiche is a common Western Australian species. *L. splendens* Er., abundant in Queensland, shows immense variation in size and in the form of the mandibles of the male; it measures from 12 up to 35 mm. in length, and the largest males have long, upcurved mandibles as much as 15 mm. long, bifid at their tips and armed with teeth on the inner side; the colour of this beetle varies from metallic reddish bronze through gold and green to purple. The finest of all Australian stag-beetles is the magnificent *Phalacrognathus muelleri* Macl. (pl. 15, fig. 19), a rare species confined to North Queensland; the elytra are wonderfully burnished, reflecting a deep metallic carmine with rich green edgings.

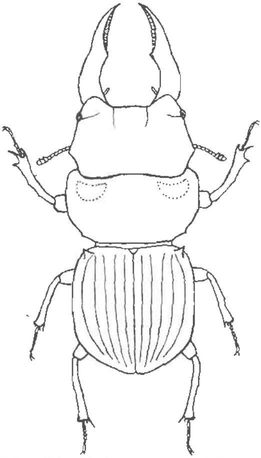


FIG. R58. *Hoplogonus simsoni* Parry, Tasmania, male, fam. Lucanidae. Length 28 mm. Note the humeral spines on elytra. [*R. J. T. del.*

Family 64. **Trogidae** [Aus. 35, N.Z. 0]. This small family, for long considered as only a subfamily of the Scarabaeidae, is really intermediate between

the latter and the Lucanidae; it agrees with the latter in having only five visible abdominal sternites, in the elytra completely covering the abdomen, in the large basal anal cell of the hindwing and in the form of the male genitalia; on the other hand, the structure of its antennae and its general facies resemble those of Scarabaeidae. Fore legs feebly spined, not formed for digging; hind coxae contiguous. The beetles are black, heavily sculptured and of peculiar shape, with the head placed vertically beneath the fore part of the pronotum. The finest of the Australian species are *Megalotrox dohrni* Har. (pl. 18, fig. 29), *Trox gigas* Har. and *T. elderi* Blkb., all measuring up to an inch in length; they feed on decaying animal matter, old skins, etc.

Family 65. **Scarabaeidae** (Chafers) [Aus. 1869, N.Z. 88]. Antennae with from three to eight lamellate segments, the lamellae closely coadapted with one another and capable of being separated or held close together as a compact club; mandibles not strongly developed in the male; sexual dimorphism usually absent or slight, though in some groups the males are much larger than the females and are armed with horns on head or prothorax; elytra usually not completely covering abdomen, leaving pygidium exposed; legs more or less fitted for digging, especially the forelegs; fore coxae always contiguous; abdomen with six visible sternites and an extra segment visible laterally. Larvae (fig. R11) soft, curved melolonthoid grubs, living in soil, dung, etc.

This immense family is represented in Australia by seven well-marked subfamilies, of which only four are found in New Zealand.

The Scarabaeinae (Coprinae) or Dung Beetles have only a single spur on hind tibiae, and antennae with 9-10 segments; they are somewhat poorly represented in New Zealand, owing to the absence of large mammals. *Saphobius* contains small squat species and is the only genus represented in New Zealand. The almost world-wide genus *Onthophagus* occurs in Australia, one of the finest species being *O. pentacanthus* Har., 18 mm. long, broad and black, with four large spines on pronotum and a long vertical spine on the head. The peculiar species of *Cephalodesmius* roll balls of earth together and lay their eggs in them. *Aulacopris reichei* Wh. (pl. 18, fig. 30) is a large species, dull black, with tuberculate elytra, superficially resembling a *Trox*. *Macropocopris symbioticus* Arrow (fig. R59) is a small species which lives in the anus of wallabies (*Macropus* spp.) and has large, hooked

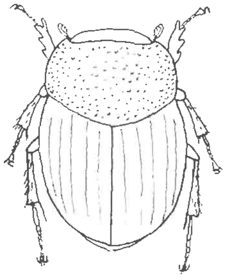


FIG. R59. *Macropocopris symbioticus* Arrow, Australia, fam. Scarabaeidae, subfam. Scarabaeinae (Coprinae). Length 3.8 mm. [*A. Tonnoir del.*

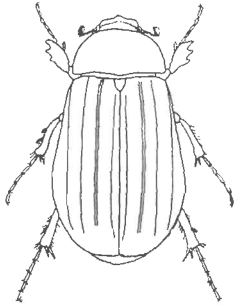


FIG. R60. *Odontria zealandica* Wh., Bronze Beetle of New Zealand, fam. Scarabaeidae, subfam. Melolonthinae. Length 9 mm. [*A. Tonnoir del.*

claws resembling those of the ectoparasitic Diptera (figs. W72, 73); these claws are well adapted for holding tightly to the rapidly moving host.

The Aphodiinae are another group of dung-feeding beetles, mostly of small size and dull coloration; they are of slenderer form than the Scarabaeinae and have two spurs on the hind tibiae and antennae with 9 segments. The genus

Aphodius has numerous species in both countries. The blind *Phycochus graniceps* Broun is found near sea-beaches in New Zealand and Tasmania.

The Geotrupinae are a peculiar group, absent from New Zealand, distinguished by their 11-segmented antennae; they burrow deep down into the soil, stridulate loudly and fly readily to light. Most of the Australian species belong to the genus *Bolboceras*, broad, reddish or brownish beetles measuring up to about 20 mm. in length and remarkable for the peculiar sculpture of the head in the males. *B. capreolus* Wwd. from Western Australia is the most striking species; *B. rhinoceros* Macl. is common in Queensland.

The above subfamilies agree in having all the abdominal spiracles placed on the pleural membrane between tergites and sternites. In the remaining groups, the spiracles are situated in part on the pleural membrane and in part on the sternites, the former being the more anterior, the latter the more posterior of the series; in addition, the first four pairs are large and oblong, the last three pairs small and rounded, and the last (seventh) pair is always visible when the elytra are closed, either on the fifth visible sternite (the true seventh sternite) or on the inferior margin of the propygidium.

The Melolonthinae are an immense group, commonly known as Cockchafers; there is little or no difference between the sexes and the last three pairs of spiracles are placed almost in line with the rest. There are nearly a thousand Australian species and about 60 in New Zealand. A large number of them are injurious either in the larval or adult stage. The very injurious larvae known as Grass-grubs belong to this group. In New Zealand, the common grass-grubs are the larvae of the genus *Odontria*, of which the commonest species are the smooth brown *O. zealandica* Wh. (fig. R60) and the somewhat larger and darker brown *O. striata* Wh. with hairy elytra. These larvae have no natural enemies except birds, and frequently increase to such an extent as to ruin completely large areas of pasture. The Manuka Beetle, *Pyronota festiva* Fabr. (pl. 2, fig. 13) is a beautiful green cockchafer about 10 mm. long, found clustering in large swarms on Manuka (*Leptospermum scoparium*) during November and December; it forms one of the principal foods for trout during those months, but also does occasional damage to orchards. *Scythrodes squalidus* Broun is a dull black cockchafer about half-an-inch long, not uncommon. The two finest of the New Zealand species are *Chlorochiton suturalis* Fabr. (pl. 2, fig. 12) and the rarer mountain species *Costleya discoidea* Broun, about the same size, with delicate olive-green elytra, prettily striated.

In Australia, the dominant genus is *Heteronyx* with nearly 400 named species; these are very ordinary looking, brown or black cockchafers, very difficult to name accurately, owing to the close similarity of many of them. Some of the commonest of the Australian grass-grubs are larvae of this genus, while the adults of a number of species damage orchards at night-time. *H. jubatus* Blkb., 6 mm. long, is common in Tasmania. The genus *Scitala* contains very similar beetles; immense numbers of *S. pruinosa* Dalm. attack fruit-trees in Tasmania at night, defoliating them and making a noise like that of bees swarming. The very beautiful, brilliant green cockchafers of the genus *Diphucephala* are also very injurious to fruit trees and their larvae are serious pests as grass-grubs. They are naturally associated with wattles (*Acacia*), but sometimes swarm in countless numbers on fruit-trees, bending the branches with their weight and completely defoliating them. The commonest species are *D. colaspidoides* Gyll., *D. aurulenta* Kby., *D. rufipes* Waterh. and *D. elegans* Blkb., all found in Eastern Australia; the first two also occur in Tasmania. *Phyllotocus* is a primitive Australian genus containing numerous, small, rather pretty cockchafers found swarming on flowers; the rich brown *Ph. ruficollis* Macl. and the allied *Ph. macleayi* Fisch, with the elytra darkened apically, are both very common. *Liparetrus* is a genus of rather similar small chafers with hairy pronotum, mostly found on eucalypts; *L. discipennis* Guer. is a common species, 6 mm. long, blackish, with large, oval, orange-brown patches on the elytra. The allied genus *Cheiragra* has remarkable claws on the fore tarsi of the male. In the males of *Diphyllocera* the antennae are of very curious form. Of larger species, a considerable number are included in the genera *Lepidiota*, *Pachytricha*, *Haplonycha* and *Pararhopaca*. *P. gigas* Lea, from South Australia, is a dark brown, very bulky cockchafer about 33 mm. long. *Systellopus* and *Enamillus* include many handsome species, of which *E. mauricei* Blkb. is one of the most striking. *Stethaspis* (*Xylonychus*) contains fine species resembling Rutelinae, the best known being *S. eucalypti* Bd. The abnormal genus *Macchidius*, with oblong, parallel-sided elytra, contains numerous species which live in ants' nests; *M. tibialis* Blkb. is found in termitaria.

In Queensland the sugar-cane industry suffers great losses from the attacks of larvae of large species of Melolonthinae: the worst of these is the Greyback Sugar-cane Beetle, *Lepidoderma albohirtum* Waterh., a large chafer over 30 mm. long, mostly black beneath, with brown head and pronotum, the elytra covered with pale greyish-white scales; its larvae attack the roots of growing cane. Several species of *Lepidiota* are also injurious to sugar-cane. A comprehensive account of these beetles and their control is given in a paper by Illingworth and Dodd.

In Australia the larvae of Melolonthinae are preyed upon by three important groups of beneficial insects, all absent from New Zealand, viz., the Scoliid wasps, the Thynnid wasps and the Moth lacewings (fam. Ithonidae). The wasp larvae are internal parasites; the larvae of Ithonidae (fig. U7, A) are burrowing, predatory grubs resembling their prey, but provided with short, sucking jaws. Attempts have been made to acclimatize these valuable insects in New Zealand, but so far without success.

The Rutelinae are mostly large, brightly-coloured chafers, having the last three pairs of spiracles diverging strongly away from the line of the previous four, and with the tarsal claws unequal. They are absent from New Zealand, but well represented in Australia. The genus *Anoplognathus* contains the handsome "King Beetles", found clinging to the leaves of eucalypts and other native trees and bushes. The commonest species is *A. porosus* Dalm., about 20 mm. long, light brown in colour. *A. olivieri* Dalm., about an inch long, is brown with lovely green reflections on head and pronotum. The finest species is the Sydney "King Beetle," *A. viridi-aeneus* Don. (fig. R61), measuring up to 35 mm. in length, metallic greenish bronze. *Anoplostethus opalinus* Brullé from Western Australia is about an inch long, opalescent green. *Repsimus manicatus* Swartz, about 20 mm. long, is dark bluish with purplish brown pronotum; the male has immensely developed hind legs with large, triangular tibiae. *Epichrysis lamprimoides* Wh., about 20 mm. long, is a brilliant green species from Western Australia, with a hairy head and thorax and punctiform elytra. The most beautiful species in the subfamily belong to the Queensland genus *Calloodes*; two of the best known are *C. grayanus* Wh. (pl. 15, fig. 20) and *C. mastersi* Macl. (pl. 15, fig. 21), the latter sometimes very abundant on eucalypts.

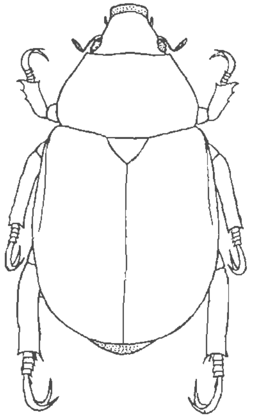


FIG. R61. *Anoplognathus viridi-aeneus* Don., Australia, fam. Scarabaeidae, subfam. Rutelinae. Length 33 mm. [R. J. T. *del.*

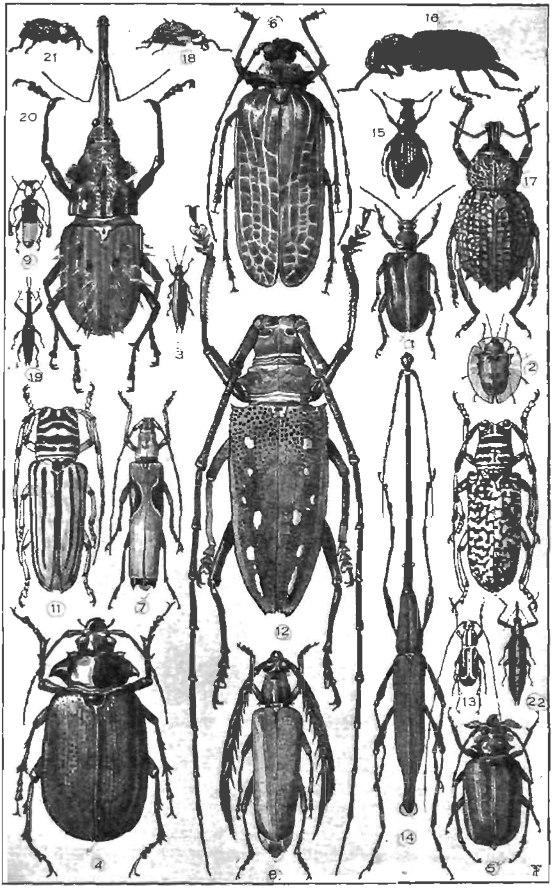
The Dynastinae differ from the Rutelinae in having the tarsal claws equal and the males often very large and armed with horns on head and prothorax: the fore coxae are transversely placed and deeply embedded. Several species occur in New Zealand, all belonging to the genus *Pericoptus*; *P. punctatus* Wh., an inch long, is black with brown hairs and brown legs; its larva (fig. R11) is found in rotten wood. Of the Australian species, the Queensland Elephant Beetle, *Xylotrupes australicus* Thoms. (pl. 18, fig. 31) is a huge black beetle in which the male has a bifid horn projecting forward from the pronotum and a larger, two-pronged horn projecting forwards and upwards from the head. The male of *Haploscapanes barbarossa* Fabr. from Northern Australia is even larger and very broad in proportion; it is shiny black, with a small curved horn projecting upwards from the head. *Eupatorus australicus* Arrow is another large black species from the tropics; the male has two short horns on the pronotum and a larger, upcurved horn on the head. The genus *Pseudoryctes* contains twelve remarkable species with peculiar pronotal armature, *Ps. trifidus* Blkb. (pl. 18, fig. 32) and *Ps. monstrosus* Blkb. being perhaps the most striking. In *Novapus* the prothorax is

Plate 19

COLEOPTERA (Phytophaga and Rhynchophora)

All figures natural size, except figs. 3, 9, and 19

1. *Megamerus kingi* Macl. (Fam. Chrysomelidae)
2. *Chirida maxima* Blkb. (Fam. Chrysomelidae).
3. *Eurispa vittata* Baly. (Fam. Chrysomelidae), (x 1.3).
4. *Sceleacantha gigas* Cart. (Fam. Cerambycidae), female
5. *Tillyardia mirabilis* Cart. (Fam. Cerambycidae), male.
6. *Prionoplus reticularis* Wh. (Fam. Cerambycidae), female. N.Z.
7. *Uracanthus triangularis* Hope (Fam. Cerambycidae).
8. *Piesarthrius frenchi* Blkb. (Fam. Cerambycidae), male.
9. *Telocera wollastoni* Wh. (Fam. Cerambycidae), (x 2)
10. *Penthea saundersi* Pasc. (Fam. Cerambycidae).
11. *Rhytiphora dallasi* Pasc. (Fam. Cerambycidae).
12. *Batocera boisduvali* Hope (Fam. Cerambycidae), male.
13. *Xenocerus leucogrammus* Mots. (Fam. Anthribidae).
14. *Lasiorrhynchus barbicornis* Fabr. (Fam. Brenthidae), male, N.Z.
15. *Tocris latirostris* Broun (Fam. Curculionidae), N.Z.
16. *Phalidura grandis* Ferg. (Fam. Curculionidae), male.
17. *Leptops areolatus* Blkb. (Fam. Curculionidae), female.
18. *Catasarcus spinipennis* Fhs. (Fam. Curculionidae).
19. *Rhadinosomus lacordairei* Pasc. (Fam. Curculionidae), (x 1.3).
20. *Eurhamphus fasciculatus* Shuck. (Fam. Curculionidae).
21. *Rhaciodes bicaudatus* Bd. (Fam. Curculionidae).
22. *Belus suturalis* Bd. (Fam. Curculionidae).



P. Tillyard del.

COLEOPTERA (PHYTOPHAGA AND RHYNCHOPHORA)

always excavated above; *N. bifidus* Lea was taken in a termitarium in Queensland. In *Corynophyllus* the males have antennae with very large, flabellate segments. *Cavonus* and *Aneurystypus* include some interesting species of medium size. *Cryptodus* is a genus with peculiar mouth-parts and antennae; all the species live in ants' nests, and are the largest inquilines known from Australia, measuring from 8 to nearly 20 mm. in length; one of the largest is *C. paradoxus* Macl., dull blackish in colour.

The Cetoniinae (Flower Chafers, Rose Chafers) are a magnificent group of elegant, flower-haunting forms, chiefly confined to the warmer parts of Australia, and entirely absent from New Zealand. They differ from the Dynastinae in having the fore coxae prominent and less transversely placed, from the Rutelinae in having the tarsal claws equal, and from both in the elytra being considerably flatter; sexual differences small or absent. The great genus *Cetonia* is represented by several handsome species of medium size and dark colouring; one of the most prized is *C. fasciculata* Macl. from the Dorrigo Scrub. The Fiddler Beetle, *Eupoecila australasiae* Don. (pl. 15, fig. 23) is common in Eastern Australia in November, visiting the flowers of *Angophora*. *E. inscripta* Jans. from Western Australia, is brownish, with black zig-zag markings on the elytra and an inverted black W on the pronotum. *Diaphonia* contains larger brown species with black markings, one of the commonest being *D. dorsalis* Don. with brownish pronotum and elytra, both marked in the middle with black. *Microvalgus* contains the smallest species of the group, and is the only genus found in Tasmania. The largest Australian species belong to the genus *Dilochrosis*; *D. balteata* Voll., 40 mm. long, is black with large red patches on the elytra. *Lomaptera* contains beautiful tropical species of glossy green or brassy colouring, one of the finest being *L. yorkiana* Jans. (pl. 15, fig. 22); *L. duboulayi* Thoms. is a slightly duller but more metallic green, with brownish edging to the elytra. The finest of all the Australian genera is *Trichaulax*, which contains large, dark species with longitudinal grooves on the elytra; *T. phillipsi* Schr. (pl. 18, fig. 33) is dull fuscous, with the grooves of the elytra filled with pale brownish hairs; *T. trichopyga* Thoms. is somewhat larger, about 30 mm. long, with narrower grooves having a little hair distally; the apices of the broad elytra are heavily clothed with long hairs of a bright orange-brown colour.

Superfamily XVII. CERAMBYCOIDEA (PHYTOPHAGA).

This group contains three very closely allied families, not easy to separate; they can all be recognized by the form of the tarsi, which have apparently only four segments, of which the three basal ones usually have a downy pad beneath, while the third is bilobed; the last segment is really the fifth, the fourth being a minute nodule at its base (fig. R65). Coupled with this is the absence of those important characters which distinguish the next group, Curculionoidea, in which the tarsi are of similar form. The venation is closely similar to that of Cucujoidea, but there are many aberrant forms. The larvae are all vegetable feeders; both larvae and beetles differ greatly in form according to whether they feed externally on leaves or internally in wood. The group is apparently derived from the Cucujoidea by way of forms like *Parandra* (p. 199). The families are distinguished as follows:—

1. Antennae long or very long, often placed on frontal prominences; tibial spurs present; usually elongate beetles, often with upper surface pubescent. Fam. 66. CERAMBYCIDAE
   Antennae usually of moderate length, never placed on frontal prominences; tibial spurs absent; mostly more or less oval or rounded, convex beetles. 2
2. Head projecting as a broad, short muzzle; submentum arising basally from a narrow stalk; elytra shortened, exposing pygidium. Fam. 68. BRUCHIDAE
   Head usually without a projecting muzzle; submentum not as above; elytra usually entirely covering abdomen. Fam. 67. CHRYSOMELIDAE

Family 66. **Cerambycidae** (Longicorns) [Aus. 860, N.Z. 240]. Mostly elongate beetles of moderate to very large size; the antennae greatly elongated, often much longer than the body, generally situated on raised frontal prominences, with the eyes more or less embracing their bases; tibial spurs usually present; elytra frequently pubescent; hind coxae transversely placed; abdomen with five free visible sternites and a sixth sometimes visible, especially

in males. Larvae (fig. R62) whitish, elongate grubs, with small head, large mandibles, thorax often more or less swollen, legs very small or absent; borers into the wood of living or fallen trees. There are three distinct subfamilies.

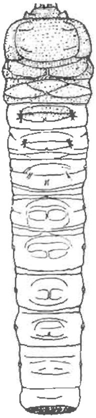


FIG. R62. Larva of *Prionoplus reticularis* Wh., New Zealand, fam. Cerambycidae, subfam. Prioninae. Length 68 mm. [*R. J. T. del.*

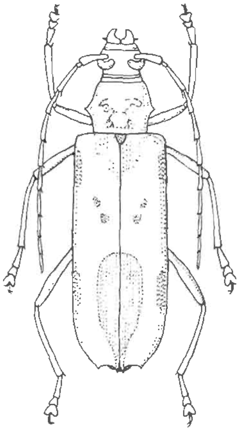


FIG. R63. *Phoracantha synonyma* Newm., Australia, fam. Cerambycidae, subfam. Cerambycinae. Length 32 mm. (The heavy pitting on the elytra is omitted.) [*R. J. T. del.*

The Prioninae have the prothorax margined and the labrum firmly fixed *to the clypeus; the fore coxae are large and transversely placed.* New Zealand possesses only two species, both fine beetles. *Prionoplus reticularis* Wh. (pl. 19, fig. 6), the largest of all New Zealand beetles, measures up to two inches in length and is dark brown with paler reticulate venation on the elytra; it is very common and flies to light. The larva (fig. R62), called "Hu-hu" by the Maoris, is eaten as a delicacy; it bores into fallen forest timber, chiefly white pine or kahikatea (*Podocarpus dacrydioides*), and also into the introduced *Pinus radiata*. *Ochrocydus huttoni* Pasc., about 30 mm. long, is paler, uniformly brown, with longer antennae. Of the Australian species, *Eurynassa odewahni* Pasc., is a common, large brown longicorn, two inches or more in length, found on the trunks of Eucalypts. The genera *Rhipidocerus* and *Enneaphyllus* have males with flabellate antennae. *Sceleacantha* contains broad species of handsome shape, the finest being *S. gigas* Cart. (pl. 19, fig. 4) found in dense scrub on the Dorrigo Plateau. *Tillyardia* differs from *Sceleacantha* in the remarkable form of the palpi in the males (fig. R64); both pairs are enlarged into open-ribbed, basket-like organs. *T. mirabilis* Cart. (pl. 19, fig. 5) the only known species, flies swiftly like a cockchafer over grass-lands wet with dew on the Dorrigo Plateau; only the male being known, it is possible that the female is actually *S. gigas* Cart.,* though the size and habits of the two are very different.

The Cerambycinae have the prothorax not margined, the labrum free and the *fore tibiae not grooved: the fore coxae are rounded and the last segment of the maxillary palpi broader than the rest, not pointed.* They are mostly slender, typical longicorns, and are abundant in both countries. Many of them do considerable damage to forest trees, the larvae as a rule feeding in galleries between the

*If so, the correct name would be *Tillyardia gigas* (Cart.).

wood and the bark, and often entirely ring-barking twigs and small branches of large trees or the main stems of smaller ones. Of the New Zealand species, a large number belong to *Aemona* and *Didymocantha*; *D. cognata* Broun, 15 mm. long, is handsomely marked in black and brown. *Leptachrous strigipennis* Wwd., 15 mm. long, is shiny brown with striated elytra. *Navomorpha lineata* Fabr.*

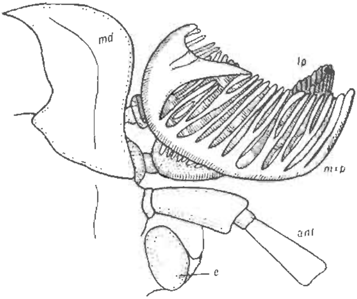


FIG. R64. *Tillyardia mirabilis* Cart., male. Australia. fam. Cerambycidae, subfam. Prioninae. Dorsal view of right side of head, to show the remarkable palpi; *ant*, antenna; *e*, eye; *lp*, labial palpus; *md*, mandible; *mxp*, maxillary palpus. (x 11). [*R. J. T. del.*

(pl. 2, fig. 15), *Calliprason sinclairi* Wh. (pl. 2, fig. 14) and the little *Zorion minutum* Fabr. (pl. 2, fig. 16) are three of the most beautiful species; the last named is commonly taken by beating foliage. Species whose larvae do damage in forest reserves are *Aemona villosa* Fabr., an inch long, a very pubescent, brownish species with orange scutellum, *Ambeodonta tristis* Fabr., half-an-inch long, dark brown, *Ophryops dispar* Sharp, 18 mm. long, yellowish brown, and the somewhat larger, duller and more pubescent *O. setaceus* Broun.

Amongst the large number of Australian species, those of the genus *Phoracantha*, with spines on prothorax and apices of the heavily pitted elytra, are amongst the commonest; they are of fair size, 20 to 40 mm. long, and mostly patterned in dark brown and yellow; they are often found in houses, being introduced with firewood; hence the vernacular name "firewood beetles." The larvae live in various species of Eucalyptus, feeding at first under the bark and then penetrating into the wood. The commonest species are *Ph. tricuspis* Newm., *Ph. semipunctata* Fabr., *Ph. synonyma* Newm. (fig. R63) and *Ph. recurva* Newm.; the last-named has been introduced into New Zealand and South Africa, where it attacks Blue Gum (*Eucalyptus globulus*). *Uracanthus* contains long, cylindrical species in which the femora carry curious lines of hairs charged with a sticky substance: *U. triangularis* Hope (pl. 19, fig. 7) is pale greyish brown with a large triangular blotch of dark brown on each elytron; *U. cryptophagus* Oll. is nearly two inches long, buff-coloured; its larva damages orange trees. *Tessaromma* contains much smaller species with each eye divided into two; *T. undatum* Newm. and *T. sericans* Er. are common species which have been introduced into New Zealand. The males of *Piesarthrius* and *Distichocera* have flabellate antennae; *P. frenchi* Blkb. (pl. 19, fig. 8) is brown with white scutellum and white markings on pronotum; its larva damages wattles (*Acacia*). *D. macleayi* Newm. and allied species attack Eucalypts; the males of this genus are smaller, more slenderly built and more darkly coloured than the females. *Tragocerus lepidopterus* Schr. measures up to 40 mm. in length and is rich reddish brown with patches of pale yellow hairs on the elytra; *T. formosus* Pasc. is smaller but even more beautiful. The "bardee" of Western Australia, *Bardistus cibarius* Newm., ranges right across to New South Wales; its larvae

*The figure of this species is too brightly coloured; it should be reddish black.

are found in the stems of grass-trees and "black-boys" (*Xanthorrhoea*) and are eaten both by aborigines and white people. *Telocera wollastoni* Wh. (pl. 19, fig. 9) is a small species, red and blue-black in colour, with clubbed antennae. *Purpuricenus angasi* Wh. (pl. 15, fig. 26) is a tropical species of exceptional colouring for this family. *Syllitus*, *Pterostenus* (*Stenoderus*) and other genera give out a scent of carbolic acid, and are distasteful to birds.

Amongst the Australian species, there are a considerable number which mimic other insects. The excessively slender species of *Lygesis* resemble the Coreid bugs of the genus *Leptocorisa*. The small, slender and distinctively marked species of *Zoedia* resemble ants, while the species of the genera *Brachopsis*, *Cyclocranium*, *Ametrocephala* and *Formicicomus* have heads like those of ants. In the tropics, the species of *Clytus* hunt about on flowers and tree-trunks just as ants do. The handsome *Aridaeus thoracicus* Don. (pl. 15, fig. 24), found commonly on tea-tree (*Leptospermum*), has a striking coloration which gives it a certain amount of resemblance to a wasp. But the most remarkable case of mimicry is that of the genus *Hesthesis*, in which the elytra are greatly shortened, the long hindwings lie flat along the abdomen without being folded at the tips, and the coloration is strikingly like that of certain wasps of the family Thynnidae. These beetles visit flowers and move with the jerkiness and flicking of their wings that are characteristic of the wasps which they mimic, so that it is no wonder that they are often mistaken for wasps by collectors. *H. ferruginea* Bd. (pl. 15, fig. 25) is the finest species; *H. cingulata* Kby. is blackish, with three white bands around the abdomen.

The Lamiinae differ from the Cerambycinae only in having the fore coxae round and usually deeply embedded and the fore tibiae obliquely grooved on the inner side. Most of the species are of stouter build than the Cerambycinae. Of the very numerous New Zealand forms, the peculiar genus *Tetrorea* includes fairly stout, brownish species, 10 to 20 mm. long, with two dorsal and two lateral processes on the pronotum. The great genus *Somatidia* contains about 60 species of mottled greyish, stout, spider-like longicorns, rugosely sculptured; *S. antarctica* Wh. is one of the commonest. *Xylotoles* contains numerous small, dull-coloured species. *Diastamerus tomentosus* Redt., 15 mm. long, is dark brown and hairy all over. *Hexatricha pulverulenta* Wwd., 18 mm. long, is mottled brown, with peculiar hairy antennae, banded alternately with fuscous and pale yellowish.

In Australia, the Lamiinae are represented by a number of very fine species, mostly of grey, fuscous or black coloration, often speckled or striped. *Symphyletes* is a large genus of fine and handsomely shaped species in which the males have the fore coxae armed: one of the best known species is the mottled brown, buff and grey *S. vestigialis* Pasc., 18 mm. long, found on wattles. *Penthea* contains many fine species not unlike the preceding, such as the handsome *P. saundersi* Pasc. (pl. 19, fig. 10), speckled black and white. *Rhytiphora dallasi* Pasc. (pl. 19, fig. 11) is handsomely striped in black and silver; *Rh. frenchi* Bd. is stouter, with three narrow rings of white round the prothorax, the elytra heavily speckled with white all over, and antennae with narrow white annulations. The very handsome *Glenea picta* Fabr. (pl. 15, fig. 27) is found in Papua and North Queensland. *Thyada barbicornis* Pasc. has very beautiful antennae. *Dorcadida* contains strongly sculptured species found in Tasmania. *Ceraegidion horrens* Bd., 18 mm. long, is a rather slender, spiny species, dull fuscous. *Demonassa macleayi* Pasc. is larger and stouter, blackish with fine white speckling, and has two pairs of spines on the pronotum and a large vertical spine on each elytron. *Athemistus* and *Microtragus* are genera shaped like Phalidurine weevils; *M. luctuosus* Shuck., 17 mm. long, is very rugose, dark fuscous. *Mesolita myrmecophila* Lea is a very curious species found with ants in Queensland. *Periaptodes*, *Callipyrga* and *Monohammus* are genera containing fine, large species; the last-named has many species outside Australia. The finest of all the Australian Lamiinae belong to the genera *Batocera* and *Rosenbergia*, whose larvae bore into native fig-trees; they occur in the Northern Territory, Queensland and northern N.S.W. These beetles are of enormous size, and have been captured in considerable numbers by cutting pieces out of the bark of a fig-tree so that the sap flows freely; the beetles fly to the sap after dark. *B. frenchi* Blkb., from North Queensland, and *B. boisduvali* Hope (pl. 19, fig. 12), from South Queensland and northern N.S.W., are the best known species. *Rosenbergia megacephala* Poll. is equally large, with its white, pubescent cuticle covered with shining granules; it comes from the Northern Territory.

Family 67. **Chrysomelidae** (Leaf Beetles) [Aus. 1872.* N.Z. 183].

*Mr. A. M. Lea's estimate is 1986.

Usually broad, oval or rounded beetles of small to moderate size; head not produced forward into a muzzle; antennae of moderate length, not placed on prominences, their bases not partially embraced by the eyes; integument nearly always smooth, shining, devoid of hair or pubescence. Larvae (fig. R12) of varying colours, with short legs; mostly feeding on leaves. This enormous family is divided into a number of subfamilies, of which ten occur in Australia but only five in New Zealand.

The Sagriinae are the largest and most primitive forms, having the prothorax without a margin but with a distinct prosternum; in general shape they resemble Lagriidae. *Megamerus kingi* Macl. (pl. 19, fig. 1) from Cape York, is dark shining brown. *Mecynodera coxalgica* Bd., is 14 mm. long, intricately marked in black and dark red. *Carpophagus banksiae* W.S.M. is of similar size and shape but unicolorous dark brown. *Sagria papuana* Jac. from North Queensland, is a deep metallic blue beetle an inch long; it is known as the "Kangaroo Beetle" because of its large hind legs.

The Criocerinae differ from the Sagriinae in having a very narrow prosternum; they are absent from New Zealand; most of the Australian species belong to world-wide genera. *Stethopachys formosa* Baly is a handsome species which lives on epiphytic orchids (*Dendrobium* spp.). The Clytrinae are a small group having the fore coxal cavities congruent and the pygidium exposed; they are absent from New Zealand, but represented in Australia by very small species belonging to the genera *Diaphromorpha* and *Leasia*. The Cryptocephalinae, found in both countries, differ from the previous group in having the fore coxal cavities separated by the prosternum. *Arnomus* contains most of the New Zealand species, while *Cadmus* and *Cryptocephalus* are well represented in Australia. *Ditropidus* is an immense genus of small, shining, pill-like beetles, often distinctively coloured. *Loxopleurus* also contains many brightly coloured Australian species.

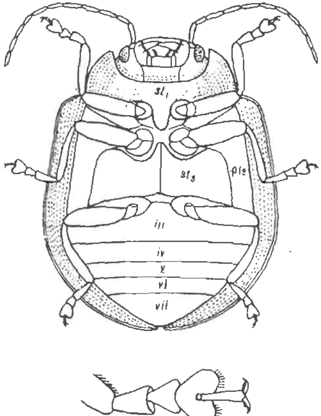


FIG. R65. *Paropsis gibbosa* Blkb., Australia, fam. Chrysomelidae, subfam. Chrysomelinae. Length 11 mm. Below, fore tarsus enlarged. *iii–vii*, abdominal sternites; *pl*, pleurum; *st*, thoracic sternum. [*R. J. T. del.*

The immense subfamily Eumolpinae, found in both countries, has the fore coxae rounded, the third segment of the tarsi deeply bilobed and the antennae widely separated at bases. New Zealand has numerous species of *Eucolaspis*, some of which do great damage by eating the leaves of garden plants, vegetables

and fruit-trees; the worst of these are the Bronze Beetle, *E. brunneus* Fabr., 3 mm. long, shiny brown, and the larger and darker *E. ochraceus* Broun. The Australian forms include the two very lovely species of *Spilopyra*. *Rhyparida didyma* Fabr., 7 mm. long, is orange-brown with a number of black spots on the elytra.

The Chrysomelinae are another huge subfamily found in both countries; they differ from the Eumolpinae in having the third segment of the tarsi entire and the fore coxae transversely oval. Most of the New Zealand species belong to the genera *Allocharis*, *Aphilon* and *Caccomolpus* and are small, without any striking characters. In Australia the genus *Calomela* contains pretty little beetles found on wattle; their elytra are yellow, mostly striped with blue or green; *C. curtisi* Kby. is one of the best known. *Stethomela* includes similar but larger species with blotched elytra. *Johannica* contains lovely species with palmate antennae. *Aesernia australasiae* Jac. (pl. 15, fig. 28) is a handsome species from the scrubs of northern New South Wales. *Augomela hypochalcea* Germ., 11 mm. long, is deep metallic greenish black with transverse narrow bands of green and fiery opal. The great genus *Paropsis* (fig. R65) contains hundreds of Australian species which feed on Eucalyptus and wattles (*Acacia*); they are very convex, broadly rounded beetles, many of which are brilliantly coloured in life, but turn dull and lose their patterns when dead. Their caterpillar-like larvae (fig. R12) often do considerable damage. The dark reddish-brown *P. immaculata* Marsham, half-an-inch long, and the much smaller *P. orphana* Er. are both very abundant at times on wattles. *P. gibbosa* Blkb. (fig. R65) is dark brown with small yellow spots on pronotum; *P. sexpustulata* Marsham, half-an-inch long, is shiny blackish with six large red blotches on the elytra; *P. vittipennis* Bohem. is the same size, with red stripes along the black elytra. Some of the smaller species of this genus closely resemble Coccinellidae.

The Galerucinae have the fore coxae prominent and conical, and the antennae inserted close together at the base. Most of the New Zealand species belong to the genus *Luperus*, small, somewhat metallic forms of rather graceful shape. In Australia the genus *Oides* contains numerous species, some beautifully marked; *Rupilia* and *Neorupilia* have short elytra, and the latter is also apterous. *Hoplostines viridipennis* Blkb. is a lovely green species which feeds on the Stinging-tree (*Laportea gigas*) in Queensland and northern N.S.W. This subfamily contains three of the worst leaf-eating pests in Australia, viz., the Pumpkin Beetle, *Aulacophora hilaris* Bd. (fig. R66), orange brown with black patches on

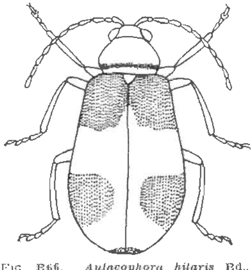


FIG. R66. *Aulacophora hilaris* Bd., Australia, fam. Chrysomelidae, subfam. Galerucinae. Length 6.5 mm. [*A. Tonnoir del.*

the elytra, *Monolepta rosea* Blkb., 3 mm. long, yellow with bases of elytra rose-red, and *M. divisa* Blkb., orange brown with darker tips to the elytra; the last-named attacks grape-vines.

The Halticinae or Flea Beetles are very small species which only differ from the Galerucinae in having the hind femora thickened and adapted for leaping. *Phyllotreta rugulosa* Broun, under 2 mm. long, is the best known of about a dozen New Zealand species. The largest Australian genus is *Arsipoda*. *Licyllus splendidus* Jac. is a beautiful little beetle which often riddles the leaves of native species of *Solanum* in Australia.

All the above groups agree in having the *frons normally placed and the* mouth anterior. There remain two specialized subfamilies, both absent from *New Zealand, in which the frons is deflexed and the mouth inferior in position.* Of these, the Hispinae are a peculiar group, often more or less elongated in form, and having the head free. *Monochirus multispinosus* Germ. (fig. R67), found on

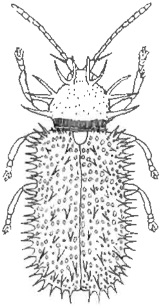


FIG. R67. *Monochirus multispinosus* Germ., Australia, fam. Chrysomelidae, subfam. Hispinae. Length 5 mm. [*A. Tonnoir del.*

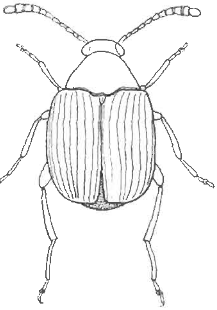


FIG R68. *Bruchus chinensis* Thunb. Australia, fam. Bruchidae. Length 3 mm. [*A. Tonnoir del.*

grass, is a short, black beetle covered with spines. Aproida balyi Pasc. is much slenderer, 10 mm. long, pale green when alive, with dark margins to the elytra, which end in sharp spines; the antennae stand out in front of the head, and the general appearance is much like that of a Coreid bug. *Eurispa* contains numerous slender species found on sedges; *E. vittata* Baly. (pl. 19, fig. 3) is a common species, conspicuously striped.

The Cassidinae or Tortoise Beetles have the head concealed beneath the pro-*thorax, which, together with the elytra, is provided with a wide flange or margin. Aspidomorpha* contains most of the Australian species. *Chirida maxima* Blkb (pl. 19, fig. 2), from North Queensland, is dark brown with transparent flanges. The larvae are very remarkable in form and cover themselves with excrement.

Family 68. **Bruchidae** (Pea and Bean Weevils) [Aus. 14, N.Z. 0]. A *small family very closely allied to the preceding, from which it is distinguished* by having the head projecting as a broad, short muzzle and the submentum arising basally from a narrow stalk; prosternum very short, perpendicular in front; elytra shortened, exposing the pygidium. Larvae, stout maggots feeding internally in seeds; when hatched they possess short legs, but these are lost later on *Bruchus chinensis* Thunb. (fig. R68) is a widespread species found in Australia, where all the native species belong to this one genus. The widespread, introduced *Bruchus rufimanus* Bohem. is a pest of dried peas and beans in both countries.

Superfamily XVIII. CURCULIONOIDEA (RHYNCHOPHORA). (Weevils).

The members of this great group, popularly known as Weevils, are distinguished from all other Coleoptera by the absence of the gular plate; hence the latero-ventral portions of the genae meet in a mid-ventral, longitudinal suture. The *head is almost always prolonged, in front of the eyes, to form a rostrum (short* or even apparently absent in a few forms), and the peculiar mouth-parts are placed at its apex. In the majority of forms the labrum is absent and the two pairs of palpi are short and rigid. Generally the rostrum has a more or less elongated groove on each side for the reception of the antenna; these grooves are called *scrobes* (fig. R69, *sb*) and their shape is made use of in classification.

The antennae (fig. R69) have from six to twelve segments, and are frequently divided into three well-marked regions, viz. the *scape* (*sc*) or elongated first segment, at the end of which the antenna is often elbowed, the *funicle* (*fn*) consisting of a variable number of filiform, moniliform or nodular segments, and a terminal *club* (*cl*), formed of 3-5 segments, rarely (Platypodidae) with the segmentation obliterated. Tarsi apparently 4-4-4, as in the preceding superfamily,

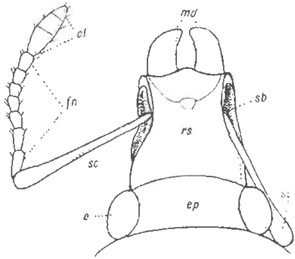


FIG. R69. Head of *Prypnus scutellaris* Fabr., Australia. fam. Curculionidae, subfam. Brachyderinae. Dorsal view (x 11); *cl.* club; *e.* eye; *ep.* epicranium; *fn.* funicle; *md.* mandible; *rs.* rostrum; *sb.* scrobe; *sc.* scape. [*R. J. T. del.*

seg. 3. nearly always bilobed.* The hindwing folds strongly at or before half-way on a pivotal area placed between the very strong veins *R* and Cu_1; two strong veins are usually present on the apical area: the returning vein, apertum and anal veins are reduced or obsolescent. This type is derived from that of the Cerambycoidea, the venation of the Anthribidae approaching very close'y to that of the latter. Many highly reduced and even wingless forms occur. Abdomen with five visible sternites (rarely six). Larvae curved or, more rarely, cylindrical grubs, with hard, rounded heads, often blind, usually legless; feeders on vegetable tissue, chiefly wood, bark, shoots and buds, more rarely on leaves, roots, grain and other stored vegetable products. The group is of the greatest economic importance, as it contains some of the most destructive insect pests known. The classification is difficult, but five families may be recognized, as in the following Key:—

1. Rostrum very short and broad, or obsolescent; antennae short, with a very strong club; one or more pairs of tibiae denticulate externally. 2
   Rostrum variable, but always well developed, usually long, often narrow; antennae with club moderate, weak or absent; tibiae never denticulate. 3
2. Head wider than prothorax; tarsi slender, with first segment very long, third segment not bilobed. Fam. 70. PLATYPODIDAE
   Head narrower than prothorax; tarsi stouter, short, with first segment not long, third segment bilobed. Fam. 69. SCOLYTIDAE
3. Labrum present; palpi flexible, filiform; submentum with a large, bilobed peduncle. Fam. 71. ANTHRIBIDAE
   Labrum absent; palpi, small, usually rigid; submentum not as above. 4
4. Rostrum horizontal, usually greatly elongated; antennae not elbowed; general form of body elongate, often very narrow. Fam. 72. BRENTHIDAE
   Beetles not having the above combination of characters; rostrum very variable; antennae distinctly elbowed in the great majority of forms, including those in which the general form of body most approaches that of the Brenthidae Fam. 73. CURCULIONIDAE

Family 69. **Scolytidae (Ipidae)** (Ambrosia Beetles) [Aus. 30, N.Z. 8]. Small, broad'y built weevils with very short, broad rostrum; head nar-

*In the Platypodidae the true fourth segment, which is a minute nodule in the other families, is clearly visible, and the third segment is not bilobed.

rower than prothorax; antennae short, not elbowed, funicle very short, club *very large; scrobes absent; labrum present; palpi very short;* tibiae compressed, often denticulate on outer margin; tarsi short, with seg. 1 short, seg. 3 entire or bilobed, ventral pads absent. Larvae a blind, legless, curved grub, mostly boring tunnels in the bark of trees. These tunnels are characteristic of the family, as

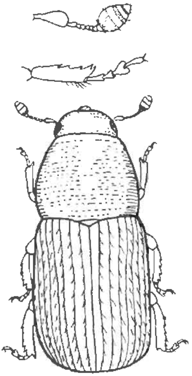


FIG R70. *Pachycotes ventralis* Sharp, New Zealand, fam. Scolytidae. Length 4.5 mm. Above, antenna and hind leg, enlarged.
[*R. J. T. del.*

FIG R71. *Platypus apicalis* Wh., New Zealand, fam. Platypodidae. Length 6 mm.
[*A. Tounoir del.*

they radiate out from a common centre, each set being the work of the progeny from a single batch of eggs. In a number of cases, the colony inhabiting one of these sets of tunnels shows a social organization of a very definite kind, the principal object being the cultivation of special fungi (ambrosia) in the tunnels; these fungi are used as food. The genus *Tomicus* is represented in both countries, *Xyleborus, Cryphalus* and *Hylesinus* in Australia, *Acrantus, Dendrotrupes* and *Pachycotes* in New Zealand; one of the best known species is the dull blackish *Pachycotes ventralis* Sharp (fig. R70).

Family 70. **Platypodidae*** [Aus. 11, N.Z. 8]. This small family differs from the preceding in the peculiar form of body, which is elongate, cylindrical, with the head somewhat wider than the prothorax; the antennae have only six apparent segments, of which four small ones form the funicle, the club being compact, flattened, with segmentation obsolete; the tarsi are slender, filiform, elongate, with seg. 1 very long, seg. 3 not widened or bilobed, the true seg. 4 visible but small. Larvae legless, blind, cylindrical grubs, living in tunnels, resembling shot-holes, in wood. The beetles also live in these tunnels and move with their fore tarsi bent backwards (fig. R71); in general appearance they resemble Bostrychidae, but the head is free and the form of antennae, tarsi, etc. very different. All the species belong to *Platypus;* one of the finest is the shiny blackish New Zealand species *P. apicalis* Wh. (fig. R71). *P. omnivorus* Lea is common in Eastern Australia and Tasmania.

Family 71. **Anthribidae** [Aus. 51, N.Z. 81]. Rostrum more or less elongated, always broad; antennae with eleven segments, not elbowed, often elongated, filiform or clubbed; scrobes present; labrum present; palpi filiform, flexible; submentum with a large, bilobed peduncle; tarsi with seg. 3 nearly

*Greek *platus* broad, *pous* foot, stem *pod-*, hence Platypodidae, not Platypidae; the allusion is to the tibiae.

always very small and embraced by the larger second segment, abdomen with pygidium exposed. Larvae, curved grubs with or without legs; mostly feeding in wood. Most of the New Zealand species belong to the genus *Anthribus*, of which

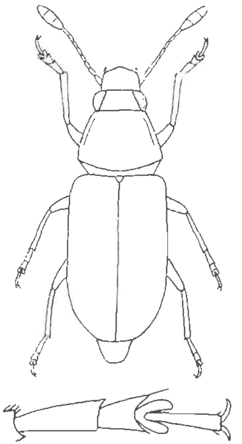


FIG. R72. *Anthribus vates* Sharp, New Zealand, fam. Anthribidae. Length 6 mm. Below, hind tarsus enlarged. [R. J. T. del.

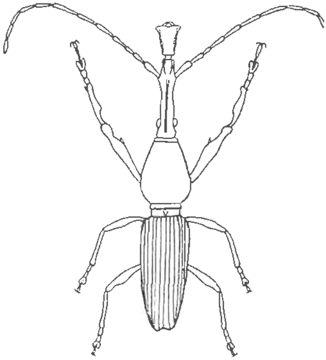


FIG. R73. *Ectocemus pterygorrhinus* Gestro, male, Australia, fam. Brenthidae. Length 25 mm. [A. Tonnoir del.

the mottled brownish *A. vates* Sharp (fig. R72) is a good example; *Exilis, Proscoporhinus* and *Dysnocryptus* also contain a fair number of species. The family is well represented on Lord Howe and Norfolk Islands, some of the species having very long antennae. *Xenocerus leucogrammus* Mots. (pl. 19, fig. 13) is a handsome, smooth species from North Queensland, brown marked with white lines. *Phloebius* contains robust Australian species 10 mm. or more in length; *Ph. gigas* Fabr. is dingy brownish, and an unnamed species from Queensland is scarlet in colour. *Doticus pestilens* Oll. has large fore legs and is capable of jumping; its larvae live in large galls of wattle (*Acacia*) and in shrivelled apples left on the trees; it has been introduced into New Zealand.

Family 72. **Brenthidae** [Aus. 27, N.Z. 2]. Weevils of slender, elongate build, with rostrum horizontal and nearly always long; antennae 11-segmented, filiform, moniliform or clavate, not elbowed; scrobes present, labrum absent; palpi short, generally hidden. Larvae similar to those of Curculionidae. The New Zealand *Lasiorrhynchus* (*Teramocerus*) *barbicornis* Fabr. (pl. 19, fig. 14) is perhaps the most wonderful species in the family; it is dark fuscous, with an immensely long, slender rostrum; the males vary in length from one to three inches, the females being smaller and with shorter antennae. Of the Australian species, the inquiline *Cordus hospes* Germ. (pl. 16, fig. 19) is a small, brown weevil found throughout the continent in the nests of ants and termites; *Ectocemus pterygorrhinus* Gestro (fig. R73) has a pear-shaped prothorax and, in the male only, the rostrum is broadened anteriorly, with strong lateral angles; the species of the genus *Eupsalis* have large, pincer-like mandibles. *Mesetia amoena* Blkb. and *Ithystenus hollandiae* Bd. have very slender elytra ending in sharp spines; the latter is black with two longitudinal reddish stripes on elytra, and the males measure up to 35 mm. in length. *Cyphagogus* and *Ionthocerus* are

curious genera found in Eastern Australia and Lord Howe Island; *Amorphocephalus* contains species of very striking form in both sexes. *Hormocerus fossulatus* Blkb. is a thick, flattened, dull brown species found under bark, the males measuring up to 40 mm.

Family 73. **Curculionidae** (Weevils) [Aus. 3246, N.Z. 1274]. Rostrum of very variable form; antennae elbowed in all except the Belinae, Eurhynchinae, Apiinae and Attelabinae, with 8-12 segments, the scape usually large, funicle of 6-7 segments (rarely 5 or 8), the club of 3-5 segments; scrobes present, very variable in form; labrum absent; palpi very short, usually rigid, sometimes concealed; tarsi generally with spongy pads beneath and with seg. 3 bilobed; abdomen with five visible sternites (rarely six), the third and fourth generally shorter than the others. Larvae (fig. R13) curved or, more rarely, cylindrical, soft, fleshy grubs, without legs, and usually blind; head hard and rounded, with strong mandibles; feeders on all kinds of vegetable material.

This immense family, abundant in all parts of the world, represents the highest and most successful development of the whole Order, and is especially remarkable for the hardness of the cuticle of most of the species (through some of which it is almost impossible to drive a pin), as well as for the high specializations in the form of the head, antennae, mouth-parts and tarsi, and the structure of the larvae. The family is divided into a very large number of subfamilies, of which no less than 42 are represented in Australia, 16 in New Zealand. It would be going beyond the scope of this book to attempt to define all these groups, but the student should note that the characters used in classification are the form of the mentum and submentum, the visibility or otherwise of the palpi, the form of the antennae and their scrobes, exposure of the pygidium, structure of tibiae and tarsi, presence or absence of wings, and general form of the rostrum.

The Brachyderinae are a small group represented in both countries by the peculiar genus *Rhadinosomus*, in which the rostrum is short but the head is elongated behind the eyes; *Rh. lacordairei* Pasc. (pl. 19, fig. 19) is a serious pest

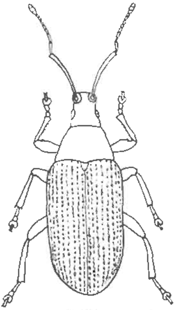


FIG. R74. *Myllocerus abundans* Lea. Australia, fam. Curculionidae, subfam. Otiorrhynchinae. Length 6 mm. [*A. Tonnoir del.*

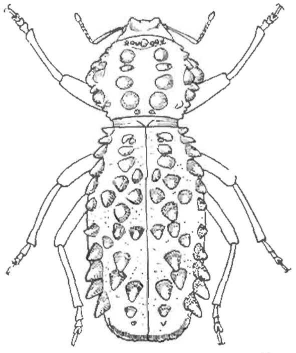


FIG. R75. *Macramycterus schoenherri* Hope. Australia, fam. Curculionidae, subfam. Phalidurinae. Length 28 mm. [*A. Tonnoir del.*

to strawberry growers in Tasmania. The Dicky Rice Weevil, *Maleuterpes phytolymus* Oll., is a root-pest of apple trees in Australia. *Ophthalmorychus* is an Australian genus with curious projections above the eyes. The genus *Prypnus*, peculiar to Australia, contains some handsome, dark species of fair size; *P. scutellaris* Fabr. (fig. R69) is shiny black, about 20 mm. long.

The Otiorrhynchinae, abundant in both countries, contain numerous small species of little interest; they have scrobes of irregular shape. The great

majority of the New Zealand species belong to the genera *Tigones, Platyomida, Catoptes, Brachyolus* and *Inophlaeus; Tigones flectiscapus* Broun is a common, brown species, 6 mm. long. Of the Australian genera, the widespread, tropical *Myllocerus* contains rather small but beautiful forms found resting on grass-stalks; *M. abundans* Lea (fig. R74) from Central Australia, is pale yellowish green. *Apirocalus cornutus* Pasc. has curious projections on the elytra; *Euphelia pardalis* Pasc. has peculiar eyes. Three European species of *Otiorrhynchus* are pests of fruit trees in Australia, the larvae injuring the roots, while the weevils attack the leaves, bark and fruit; they are *O. sulcatus* Fabr., also found in New Zealand, *O. scabrosus* Marsham, and *O. cribricollis* Fabr., the last-named doing more damage to apple trees in some districts than all other insect pests combined.

The Leptopinae, absent from New Zealand, contain some of the finest of all Australian weevils; they have a prominent, broad rostrum with linear scrobes; most of them are wingless and live on the ground. *Leptops* contains numerous species, up to an inch and a half in length, the finest being *L. gladiator* Lea from Dorrigo and *L. areolatus* Blkb. (pl. 19, fig. 17) from the dry interior of the continent. These weevils are naturally wattle-feeders, but some have become serious pests in orchards. *L. squalidus* Boh. (=*L. hopei* Fabr.), *L. rhizophagus* Lea and *L. robustus* Ol. do much damage through their larvae attacking the roots of fruit trees, especially apples. *L. tribulus* Fabr. is the common "Wattle Pig Beetle", dark brown, about an inch long, with short, blunt spines on elytra. *Cherrus* contains medium-sized species with very strong fore-legs, usually found climbing trees; *Ch. ebeninus* Fabr. is a common black species about half-an-inch long. *Catasarcus* contains numerous spiny species, mostly from Western Australia; *C. spinipennis* Fhs. (pl. 19, fig. 18) is greyish olive, with brown legs. The genus *Mandalotus*, belonging to the allied Eremninae, contains numerous small Australian species.

The Phalidurinae (Amycterinae) are a fine group of ground-dwelling, wingless weevils entirely confined to Australia and New Zealand; they have a broad, short rostrum, and a funicle of 6-7 segments; many of the species occur at high elevations. The only New Zealand genus is *Tocris*, with 7-segmented funicle; the dark fuscous *T. latirostris* Broun (pl. 19, fig. 15) is fairly common on mountains in Otago. The Australian genera have a 6-segmented funicle. The genus *Phalidura* has a large, projecting genital forceps in the male; *Ph. grandis* Ferg. (pl. 19, fig. 16) is dull fuscous, strongly tuberculate all over. *Macramycterus* contains some of the largest and handsomest of all Australian weevils, one of the finest being the Western Australian *M. schoenherri* Hope (fig. R75). Other important genera are *Talaurinus, Sclerorrhinus, Cubicorrhynchus, Tetralophus, Hyborrhynchus*, and *Acantholophus*; the two last contain spiny forms, especially numerous in Western Australia. Nothing is known of the life-history of the group; the beetles are usually found under logs or stones wandering slowly on the ground after rain.

Of a number of small, allied subfamilies we may mention the Rhyparosominae, Cylindrorhininae and Molytinae as occurring in both countries; the first-named group contains short, squat, rugose forms, extremely abundant in New Zealand, the chief genera being *Clypeorrhynchus* and *Phrynixus*; the latter also occurs in Australia. In the other two groups, there are few striking Australian species, but a number of fine New Zealand forms. *Phocodrophilus o'connori* Broun (pl. 2, fig. 17) and the handsome, large species of *Phacaphanus* and *Sargon* belong to the Cylindrorhininae, while *Lyperobius hudsoni* Broun (pl. 2, fig. 18) is placed in the Molytinae. To this latter group also belong (somewhat doubtfully) the Australian genera *Syagrius* and *Neosyagrius* containing the fern-weevils which, accidentally introduced into the Hawaiian Islands, have done great damage in the native forests there.

The Gonipterinae are a peculiar group covered with powdery meal and almost exclusively confined to Australia. *Gonipterus* and *Oxyops* are both very numerous in species; they are dingy, granulate or fasciculate weevils associated with Eucalypts. *G. reticulatus* Bd. has been introduced into New Zealand with the Tasmanian Blue-gum (*Eucalyptus globulus*). *Syarbis* contains a large number of clawless species. The Tanyrhininae, distinguished by the curious lateral edges of the rostrum, are a small group confined to Australia. The allied Aterpinae have curious processes between the eyes; the principal Australian genera are *Rhinaria, Aterpus* and *Acsiotes; Rh. perdix* Pasc. does great damage to strawberries in Tasmania. *Ac. leucurus* Pasc attacks *Pinus radiata* and other introduced pines in Australia. The clawless Australian genus *Atelicus* belongs to the Diabathriinae.

The Curculioninae (Hylobiinae) occur in both countries, but the New Zealand species, mostly included in *Eiratus* and *Bryocatus*, are not very striking. Amongst a number of fine Australian forms, we may mention the well-known Diamond Weevil, *Chrysolophus spectabilis* Fabr., found on Black Wattle; it measures up to an inch in length and is black, covered with streaks and patches of bright metallic green scales. The finest species of all is *Eurhamphus fasciculatus* Shuck. (pl. 19, fig. 20), a huge, velvety, dark brownish weevil with brushes of soft brown hairs on the immense pronotum and smaller brushes and pencils of paler hairs on the elytra: it attacks the Hoop Pine (*Araucaria Cunninghami*) in Queensland. *Orthorhinus* is a large Australian genus; *O. cylindrirostris* Fabr., *O. klugi* Boh. and *O. aethiops* Bd., known as "Elephant Beetles", are pests of citrus trees and grape-vines; the first-named is probably the commonest and most widely distributed weevil in Australia.

The Erirhininae are an immense subfamily of small or minute species, abundant in both countries. In New Zealand, the genera *Erirhinus*, *Eugnomus* and *Stephanorhynchus* contain numerous species. In Australia, the large genus *Storeus* has the segments of the funicle apparently divided into two; *Cydmaea* contains some pretty species, especially *C. luctuosa* Pasc. *Misophrice*, *Thechia* and *Anarciarthrum* are clawless genera. *Meriphrus* is a fine genus allied to some New Zealand forms and having the hind femora with a strong tooth. The fawn-coloured *Rhaciodes bicaudatus* Bd. (pl. 19, fig. 21) is one of the largest species in the group. The allied Amalactinae, absent from New Zealand, include the peculiar *Tranes monopticus* Pasc., in which the eyes are so large that they meet on the underside of the head.

The Belinae are chiefly an Australian group, but occur also in New Zealand and South America. *Belus* is a large Australian genus with some striking species found on wattles; they fly actively on summer days. *B. suturalis* Bd. (pl. 19, fig. 22) is dark brown with a pale mid-longitudinal stripe. *Rhinotia haemoptera*

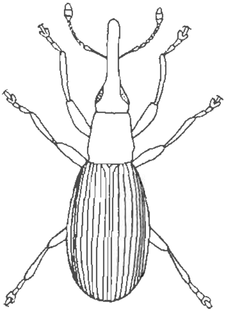


FIG. R76. ***Apion metrosideros*** Broun, New Zealand, fam. Curculionidae, subfam. Apiinae. Length 2 mm. [*A. Tonnoir del.*

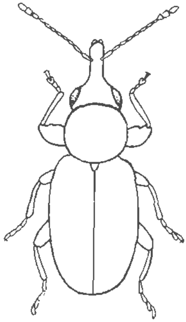


FIG. R77. ***Rhinorhynchus rufulus*** Broun, New Zealand, fam. Curculionidae, subfam. Rhinomacerinae. Length 2 mm. [*A. Tonnoir del.*

Kby. has red elytra and mimics the genus *Metriorrhynchus* (see p. 212). Most of the New Zealand species belong to *Pachyura*, *P. stictica* Broun being one of the best known; *Agathinus* contains one or two fine species up to 15 mm. in length, with velvety pubescence. The Eurhynchinae, absent from New Zealand, are a small group, represented by *Eurhynchus* and *Ctenaphides* in Australia; the latter genus has pectinate antennae in the males. A similar character marks the genus *Euops*, the only Australian representative of the small group Attelabinae. The Apiinae include some fifty Australian and two New Zealand species of small black weevils

belonging to the genus *Apion* (fig. R76). The four subfamilies mentioned in this paragraph agree in having the antennae not elbowed.

The Cyladinae include the small, black Australian species of the genus *Myrmacicelus* and the introduced *Cylas formicarius* Fabr., a pest of sweet potatoes in Eastern Australia. Four Australian species of *Magdalis* are the only representa-

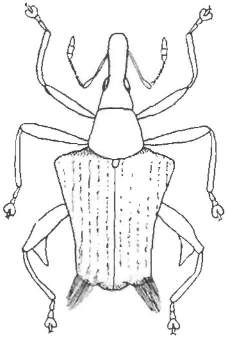


Fig. R78. *Scolopterus penicillatus* Wh., New Zealand, fam. Curculionidae, subfam. Scolopterinae. Length 5.5 mm. [*A. Tonnoir del.*

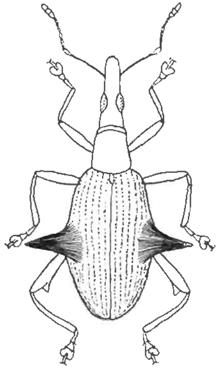


Fig. R79. *Nyxetes bidens* Fabr., New Zealand, fam. Curculionidae, subfam. Scolopterinae. Length 10 mm. [*A. Tonnoir del.*

tives of the Magdalinae. The allied Rhinomacerinae are represented by the genus *Auletes* in Australia and by a single species, *Rhinorhynchus rufulus* Broun (fig. R77) in New Zealand.

The very striking subfamily Scolopterinae is peculiar to New Zealand, where they are quite common; they are small, shiny, submetallic weevils with very narrow

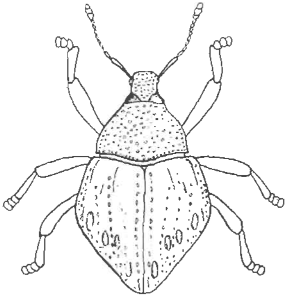


Fig. R80. *Geochus inaequalis* Broun, New Zealand, fam. Curculionidae, subfam. Haplonychinae. Length 2 mm. [*A. Tonnoir del.*

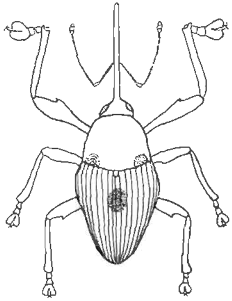


Fig. R81. *Balaninus amoenus* Fabr., Australia, fam. Curculionidae, subfam. Balanininae. Length 4.5 mm. [*A. Tonnoir del.*

head and prothorax, and the elytra armed with large, spine-like brushes of stiff hairs. *Scolopterus penicillatus* Wh. (fig. R78) is black with a slight olive-green tinge; the much larger *Nyxetes bidens* Fabr. (fig. R79) is shiny black.

Of nine small groups about to be mentioned, only the Tychinae and Haplonychinae are found in New Zealand; the former group, most abundant in Queensland, is recognized by the claws having a small appendage; of the latter, *Haplonyx* and the clawless genus *Aolles* are found in Apiomorphine galls (see p. 173) in Australia, while the genus *Geochus* (fig. R80), abundant in New Zealand, has the claws and last segment of the tarsi missing. The Balanininae are represented by some Australian species of *Balaninus* in which the female has a long, slender rostrum; *B. amoenus* Fabr. (fig. R81), black spotted with white, is common on native figs in New South Wales. Most of the species recorded as Anthonominae in Australia are now being removed to other groups; one species of *Anthonomus* alone remains. The Rhamphinae are represented by the small, black, hopping weevils of the genus *Rhamphus* which attack wattles. The Cioninae, small weevils with a 5-segmented funicle and a general resemblance to Apiinae, are sparingly represented in Australia. The Laemosaccinae contain the large genus *Laemosaccus* with exposed pygidium, well represented in Australia. The Alcidinae are abundant in Papua and include a few species of *Alcides* found in Queensland. The Menemachinae also include some curious species belonging to genera which extend beyond Australia.

The Cryptorhynchinae are an immense subfamily of timber-boring weevils, having the rostrum more or less vertical; they are represented by more than 1,000 Australian and 300 New Zealand species. *Euthyrrhinus* and the thick-headed species of *Psepholax* occur in both countries. Numerous small, dark species are also recorded for both countries under *Acalles*, but Lea has recently transferred most of the Australian species to *Decilaus*, and the New Zealand species mostly belong to other genera. *Amydala* has a very curious abdomen and hind legs; the New Zealand *Acallopais rudis* Pasc. really belongs to this genus. The Australian genus *Aonychus* is clawless. *Poropterus* is a very large genus of medium to large species abundant in Eastern Australia and Tasmania. The males of the Australian *Glochinorrhinus* have boar-like tusks. *Protopalus schoenherri* Waterh. is a large species with remarkable antennae in the male. *Axionicus insignis* Pasc. is a handsome brown and grey weevil, 10 mm. long, found on the Kurrajong Tree. *Hypomorphus melanosomus* S & J. is a remarkable species from Lord Howe Island, probably extinct by now. *Rhynchodes ursus* Wh., the New Zealand Elephant Beetle, is a large species measuring up to 20 mm., clothed all over with soft brown hair which easily rubs off.

The Zygopinae include the curious, long-legged species of *Mecopus* in which the males have two spines on the breast. The Isorhynchinae and Ceutorrhynchinae are only represented by genera which extend outside Australia. Only a single Australian species of Pantotelinae is recorded. The Baridiinae contain brilliantly metallic species of the genus *Ipsichora* and the peculiar *Myctides barbatus* Pasc., in which the male has a beard. All these small groups are absent from New Zealand.

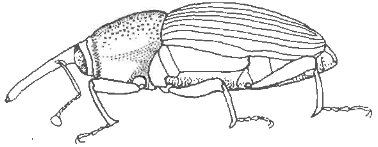


FIG. R82. *Trigonotarsus rugosus* Bd., Australia. fam. Curculionidae, subfam. Calandrinae. Length 37 mm. [*A. Tonnoir del.*

The Calandrinae have no native New Zealand species, but the few Australian species include the huge black *Trigonotarsus rugosus* Bd. (fig. R82) found in grass-trees (*Xanthorrhoea*) and the much smaller but somewhat similar *Cosmopolites sordida* Chev., the Banana Borer, which is a very serious pest in banana plantations in Australia; its life-history has been fully worked out by J. L. Froggatt. Both Australia and New Zealand suffer from the depredations of the world-wide pests known as the Grain Weevil (*Calandra granaria* L.) and Rice Weevil (*C. oryzae* L.); during the Great War, this latter species and the Bostrychid *Rhizo-*

pertha dominica Fabr. destroyed between them about eight million pounds' worth of stored wheat in Australia alone. The corn weevils of the genus *Sphenophorus* also do considerable damage in Australia.

The Cossoninae are an interesting group, specially adapted for life on oceanic

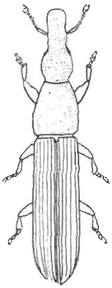


Fig. R83. *Areocryptus bellus* Broun, New Zealand, fam. Curculionidae, subfam. Cossoninae. Length 4 mm. [*A. Tonnoir del.*

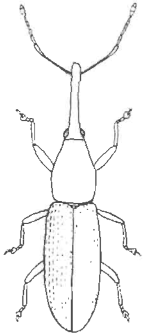


Fig. R84. *Diocdimorpha wollastoniana* Sharp, New Zealand, fam. Curculionidae, subfam. Cossoninae. Length 4.3 mm. [*A. Tonnoir del.*

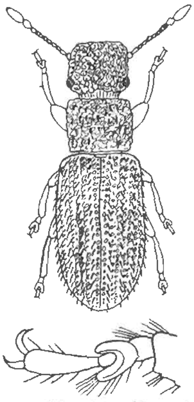


Fig. R85. *Aglycyderes wollastoni* Sharp, New Zealand, fam. Aglycyderidae. Length 3 mm. Below, hind tarsus, enlarged. [*A. Tonnoir and R. J. T. del.*

islands: they are particularly abundant in New Zealand and on Lord Howe and Norfolk Islands, but Australia has only about fifty species. They are all small species of linear, cylindrical or somewhat depressed form. The New Zealand species *Arcocryptus bellus* Broun (fig. R83) and *Diocdimorpha wollastoniana* Sharp (fig. R84) are good examples of the group. Of the numerous New Zealand genera, the most abundant in species are *Pentarthrum*, *Euophryum*, *Rhinanisus*, *Agastegnus*, *Allaorus* and *Eucossonus*; only the first of these is represented in Australia. *Pentamimus* and *Cossonus* contain a number of Australian species. The blind *Halorhynchus caecus* Woll. and *H. geniculatus* Lea occur in South and Western Australia; *Tasmanica myrmecophila* Lea is a very rare and minute, blind Tasmanian species found in ants' nests.

Superfamily XIX. AGLYCYDEROIDEA

This small group contains two families of doubtful affinities, viz., the Aglycyderidae and Proterhinidae: the latter, confined to the Hawaiian Islands, is peculiar in having the head of the male normal, while that of the female is produced into a rostrum. The Aglycyderidae contain only a single genus, *Aglycyderes*, with one species (the genotype) in the Canary Islands, two in New Zealand and one in New Caledonia; in neither sex is a rostrum present. Tarsi apparently 3-3-3 in both families, the second segment bilobed; a small nodule at the base of the distal segment (fig. R85) indicates an obsolescent penultimate segment, as in the two preceding superfamilies. The group stands nearest, perhaps, to the Anthribidae, but there

Family 74. **Aglycyderidae** [Aus. 0, N.Z. 2]. Antennae 11-segmented, filiform or with last two segments somewhat enlarged; labium rounded, hard, with small, 3-segmented palpi; maxillae with a single internal lobe and short, 4-segmented palpi; prothorax squarish; all three pairs of coxae separated; fore and middle coxal cavities rounded, hind coxal cavities oval and somewhat transversely placed; tarsi short, cuticle covered with rough scales and short setae. Life-history unknown. The type of the genus *Aglycyderes* is the Canary Island species *A. setifer* Wwd. The two New Zealand species are *A. wollastoni* Sharp (fig. R85) and *A. badius* Broun, both very rare, dull blackish beetles of small size, found occasionally under bark.

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CHAPTER XXI

Order STREPSIPTERA

This Order contains less than two hundred known species, all of which are minute insects parasitic on Hymenoptera (bees, wasps and ants) or Homoptera (leaf-and plant-hoppers). Much discussion has taken place about the relationships of the Order; but it is now generally agreed that they are related to the Coleoptera, while some authors consider them to be a specialized offshoot from the family Cantharidae.

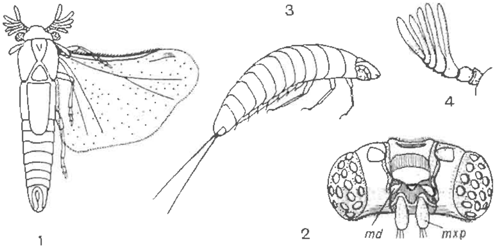

FIG. S1. *Pentozocera australensis* Perk., male, Australia (after Pierce) Fam. Halictophagidae. Length 2.2 mm.
FIG. S2. Head of same, much enlarged (after Perkins); *md*, mandibles; *mxp*, maxillary palpi.
FIG. S3. Young larva of same, lateral view, much enlarged (after Perkins).
FIG. S4. *Pentacladocera schwarzi* Perk., male, Australia. Antenna, much enlarged (after Perkins). Fam. Halictophagidae.

Characters. Minute insects with extreme sexual dimorphism, all parasitic on Hymenoptera or Homoptera.

M a l e s (figs. S1, S5) characterized as follows:—

H e a d transverse; *antennae* with 2-7 segments, one or more of which is laterally produced; *compound eyes* present, wide apart, the facets separated; *ocelli* absent. *Mouth-parts* specialized and much reduced; *labrum* and *labium* both absent; *mandibles* pointed; *maxillae* reduced, with 1-2 segmented palpi.

T h o r a x with all three segments freely movable; *prothorax* much reduced; *mesothorax* small, transverse; *metathorax* very large, greatly elongated backwards, being at least half as long as the whole body. *Legs* weakly formed, short; tibial spurs absent; tarsi with 2-5 segments, claws rarely present.

Wings:—*Forewings* reduced to a pair of small balancers, hardened like elytra, but not used to protect the hindwings. *Hindwings* large, fan-like, milky-white in colour; the concave costa with two strong veins, the rest of the veins radially arranged.

Abdomen with ten very short segments, seg. 9 overlapping seg. 10 ventrally.

Females (fig. 86):—Blind, legless, wingless, grub-like insects, living permanently in the body of the host, and partially enclosed in the pupal skin; body divided by a constriction into a fused *cephalothorax*, which projects outside the host, face uppermost, and a sac-like *abdomen* lying within the host; *mouth-parts* vestigial.

Life History. The body of the female contains an enormous number of eggs, which develop and hatch within her in the form of minute, active, six-legged larvae (*triungulins*, fig. 83) having ten abdominal segments and a pair of slender, unsegmented tail-filaments. These escape from the parent by means of a *brood-canal*, an opening between the skins of the pupa and the adult female. They swarm out on to flowers and leaves, and await the chance of getting picked up by a new host and carried to its nest or young, into which they burrow. They then change into grub-like larvae, this hypermetamorphosis being correlated with the assumption of the parasitic habit. After one more ecdysis, these grubs change into true pupae, of the *pupa libera* type, enclosed in a kind of *puparium* with a lid. At metamorphosis the females remain partially enclosed in the pupal skin, but the males emerge by lifting the lid of the puparium, and fly off. The males are exceedingly active insects of very rapid, darting flight, and live but a short time, taking no food, but searching for the females, which they fertilize *in situ*.

Distribution. Seven species representing six genera and three families are known in Australia, mostly from Queensland. All of these parasitize Homoptera, except only *Austrostylops*, whose host is unknown. The Order is not known in New Zealand.

Economics. The species which parasitize Homoptera are to be regarded as highly beneficial, the effects of their parasitism being severe enough either to destroy the host or to render it infertile. One species, *Elenchoides perkinsi* Pierce, discovered in Fiji, parasitizes the injurious Sugar-cane Leaf-hopper, *Perkinsiella vitiensis* Kirk.

Fossil History. No fossils of this order are known.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order STREPSIPTERA 7 (0)

I. MENGEOIDEA 1 (0)
  1. Mengenillidae 1 (0)

II. *HALICTOPHAGOIDEA* 5 (0)
  2. Halictophagidae 5 (0)

III. ELENCHOIDEA 1 (0)
  3. Elenchidae 1 (0)

Pierce divides the Order into five superfamilies and ten families. Of these, only three families occur in Australia. As the Order is so

little known, and more species are sure to be discovered when it is more fully worked, a complete Key to the superfamilies is here given (adapted from Pierce) :—

1. Tarsi of male with 5 segments and 2 claws. I. MENGEOIDEA
   Tarsi of male with less than 5 segments. 2
2. Spiracles of female more or less easily discernible, generally prominent. 3
   Spiracles of female not usually discernible, never prominent 4
3. Tarsi of male with 4 segments; female with 4-5 genital tubes entering brood-canal. [XENOIDEA]
   (Male unknown); female with three rows of 12 or more genital tubes entering brool-canal. [STICHOTREMATOIDEA]
4. Tarsi of male with 3 segments; head of female with apical tubercles. *II. HALICTOPHAGOIDEA*
   Tarsi of male with 2 segments; head of female with tubercles ventrally placed, more or less obsolete. *III. ELENCHOIDEA*

Superfamily I. MENGEOIDEA

Family 1. **Mengenillidae** [Aus. 1, N.Z. 0]. Antennae of male with six segments, 3-5 laterally produced, 6 elongate. This small family differs from the Mengeidae (not known in Australia) by having one segment less in the male antennae. Only two species are known, and in both cases female and host are unknown. *Austrostylops gracilipes* Lea, described from Western Australia, has very long, slender legs, the tarsi very attenuated; venation of hindwing very complete. The other species occur in Algeria (genus *Mengenilla*).

Superfamily II. HALICTOPHAGOIDEA

Family 2. **Halictophagidae** [Aus. 5, N.Z. 0]. Antennae of male with seven segments, 3-6 laterally produced, 7 elongate. This family differs from the Diozoceridae (not found in Australia) in that the latter has only 4-segmented antennae. All the Australian species are parasitic on Jassidae or Fulgoroidea. *Pentozocera* contains three species found in Queensland; *P. australensis* Perk. (figs. S1-S3) is parasitic on Jassidae. *Pentacladocera schwarzi* Perk. parasitizes the Jassid genus *Agallia* in New South Wales. *Megalechthrus tryoni* Perk. parasitizes plant-hoppers of the family *Eurybrachidae* in Queensland.

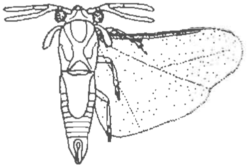

FIG. S5. *Deinelenchus australensis* Perk., *male, Australia (after Pierce)*. Fam. Elenchidae. Length 1.5 mm.

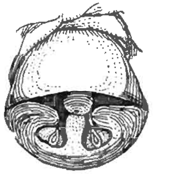

FIG. S6. Head of female of same, *protruding from host* (*Platybrachys* sp.). (after Perkins).

Superfamily III. ELENCHOIDEA

Family 3. **Elenchidae** [Aus. 1, N.Z. 0]. This, the only family of the Elenchoidea, is represented in Australia by the single species *Deinelenchus australensis* Perk. (figs. S5, 6) easily recognized by its five-segmented, two-branched antennae, two-segmented tarsi, and much reduced hindwing venation. This species parasitizes Eurybrachidae in Queensland.

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CHAPTER XXII

Order HYMENOPTERA

(Saw-flies, Ichneumon-flies, Wasps, Ants, Bees).

Characters. This is one of the most distinct of all Orders of Insects, easily recognized by the stiff membranous wings coupled together in flight by means of a series of minute hooks, by the close union of the first abdominal segment with the thorax, and by the presence of a complete ovipositor in the female, often specialized as a sting.

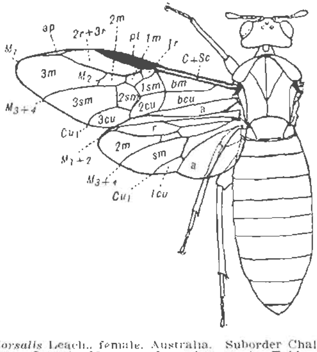


FIG. 71. *Perga dorsalis* Leach., female. Australia. Suborder Chalastrogastra, fam. Tenthredinidae. Length 26 mm. Lettering as in Table on p. 258, New Notation. [*E. S. Gourlay del.*

H e a d of very variable shape, but usually rather broad, with *compound eyes* well developed (except in a few blind, wingless forms) and wide apart; three *ocelli* usually present in a triangle on vertex. *Antennae* usually with scape, pedicel and a variable number of similar segments forming a flagellum, usually filiform or somewhat thickened, more rarely moniliform or pectinate; in some forms the scape is lengthened and the antennae elbowed between it and the other segments; in others, the flagellum may become specialized into ring-segments, funicle and terminal club (see Chalcidoidea, p. 271); in the highest groups the antennae have 13 segments in the male, 12 in the female.

Mouth-parts strongly mandibulate; labrum entire; mandibles hard, toothed; maxillae usually with lacinia, galea and five- or six-segmented palp; hypopharynx well-developed, tongue-like; labium usually with 4-

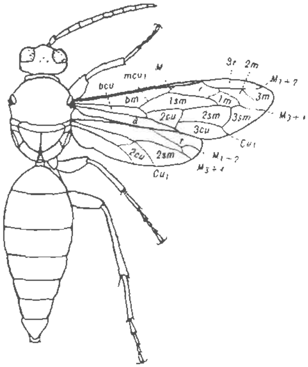


FIG. T2. *Exeirus lateritius* Shuck., male, Australia. Suborder Clistogastra, fam. Exeiridae. Length 30 mm. Lettering as in Table on p. 258, New Notation, except $r = 1r + 2r$ in forewing. [*E. S. Gourlay del.*

segmented palpi and well-developed ligula, with fused glossae and separate, small paraglossae (fig. T3).

The mouth-parts of the wasps and short-tongued bees only differ from the ordinary type in reduction of the size of the palpi, together with some slight specializations in structure of the labium and maxilla (fig. T3, D, E). In the long-tongued bees, however, a great change is noticeable; the maxillary palpi are greatly reduced, but the galea, labial palpi and the fused glossae all become greatly elongated, the last-named forming the "tongue," and ending in a small spoon (fig. T3, F, *sp*) for the extraction of nectar. Further, both maxillae and labium are hinged, the former between cardo and stipes, the latter between submentum and mentum, so that the whole proboscis can be easily withdrawn and folded down close to the head when not in use.

T h o r a x usually very compact, strongly chitinized, remarkable for the more or less complete fusion with it of the first abdominal segment, called the *propodeum* or *median segment*. The fused mass formed by union of thorax with propodeum is called the *alitrunk* (figs. T4-T6). Usually the prothorax and mesothorax are distinct, but the propodeum is closely fused with the reduced metathorax. *Prothorax* generally short but broad, the pronotum usually with two large side-lobes extending back as far as the tegulae; in some forms (fig. T6) the prothorax is merely a very short neck or collar, and the side lobes do not reach the tegulae. *Mesothorax* very large; mesonotum with large *scutum*, often divided into a central piece and two side-lobes called *parapsides*; behind it lies a large

Plate 20

AUSTRALIAN HYMENOPTERA AND DIPTERA

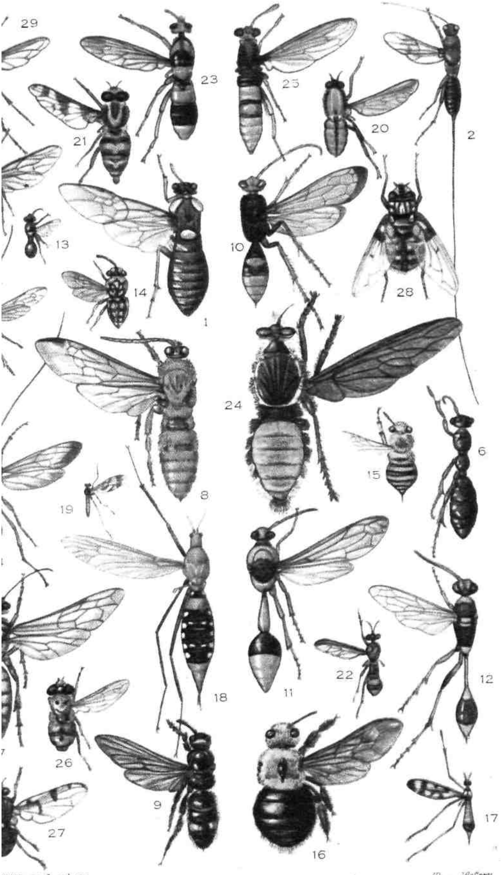
All figures natural size

Order HYMENOPTERA

1. *Perga dorsalis* Leach (Fam. TENTHREDINIDAE), female.
2. *Megalyra fasciipennis* Wwd. (Fam. MEGALYRIDAE), female.
3. *Metopius unifenestratus* Morl. (Fam. ICHNEUMONIDAE), female
4. *Trachypetus clavatus* Guer. (Fam. BRACONIDAE), male.
5. *Stilbum splendidum* Fabr. (Fam. CHRYSIDIDAE), female.
6. *Diamma bicolor* Wwd. (Fam. THYNNIDAE), female.
7. *Zaspilothynnus variabilis* Kby. (Fam. THYNNIDAE), male.
8. *Campsomeris (Trielis) ferruginea* Fabr. (Fam. SCOLIIDAE), male.
9. *Scolia (Triscolia) frontalis* Sauss. (Fam. SCOLIIDAE), female.
10. *Batozonus tricolor* Sm. (Fam. PSAMMOCHARIDAE), female.
11. *Eumenes latreilli* Sauss. (Fam. EUMENIDAE), female.
12. *Sceliphron laetum* Sm. (Fam. SPHECIDAE), female.
13. *Hylaeus (Prosopis) cognatus* Sm. (Fam. HYLAEIDAE), female.
14. *Crocisa lamprosoma* Bd. (Fam. MELECTIDAE), female.
15. *Anthophora pulchra* Sm. (Fam. ANTHOPHORIDAE), female.
16. *Xylocopa (Mesotrichia) bryorum* Fabr. (Fam. XYLOCOPIDAE), female

Order DIPTERA

17. *Gynoplistia bella* Walk. (Fam. TIPULIDAE).
18. *Clytocosmus tillyardi* Alex. (Fam. TIPULIDAE), female.
19. *Macrocera decorosa* Sk. (Fam. MYCETOPHILIDAE).
20. *Pelecorrhynchus fulvus* Ric. (Fam. TABANIDAE).
21. *Pelecorrhynchus nigripennis* Ric. (Fam. TABANIDAE).
22. *Codula vespiformis* King (Fam. ASILIDAE).
23. *Chrysopogon crabroniformis* R.D. (Fam. ASILIDAE).
24. *Blepharotes coriareus* Wied. (Fam. ASILIDAE).
25. *Diochlistus aureipennis* Wwd. (Fam. MYDAIDAE).
26. *Eristalis pulchellus* Macq. (Fam. SYRPHIDAE).
27. *Lamprogaster laeta* Guer. (Fam. ORTALIDAE).
28. *Rutilia decora* Guer. (Fam. TACHINIDAE).
29. *Rhynchiodexia longipes* Macq. (Fam. TACHINIDAE).



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AUSTRALIAN HYMENOPTERA AND DIPTERA

scutellum; axilla of forewing strongly developed; in front of each axilla is a small lateral sclerite called the *tegula*; the position of the posterior ends of the side-lobes of the *pronotum* with respect to the tegulae is of great importance in classification (figs. T4–T6). Mesopleura

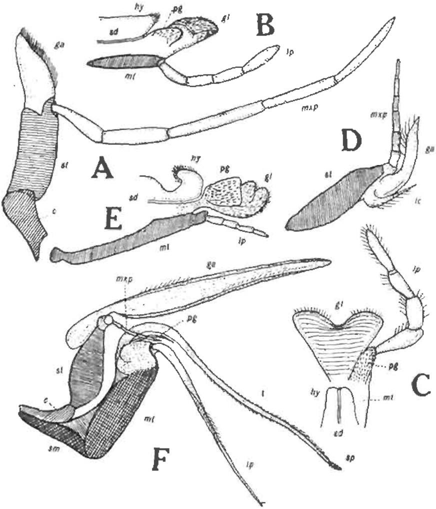
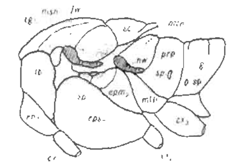


FIG. T3. Mouth-parts of Hymenoptera. A, maxilla of *Paniscus* sp., fam. Ichneumonidae (× 40); B, labium and hypopharynx of same, lateral view (× 50); C, ditto, dorsal view (× 50); D, maxilla of *Hylaeus* (*Prosopis*) *capitosus* Sm., fam. Hylaeidae (× 40); E, labium and hypopharynx of same, lateral view (× 50); F, right maxilla and labium of *Anthophora cingulata* Fabr., fam. Anthophoridae (left labial palp and paraglossa omitted), lateral view, dissected (× 16); *c*, cardo; *ga*, galea; *gl*, glossa; *hy*, hypopharynx; *lc*, lacinia; *lp*, labial palp; *mt*, mentum; *mxp*, maxillary palp; *pg*, paraglossa; *sd*, salivary duct; *sm*, submentum; *sp*, nectar-spoon at tip of tongue; *st*, stipes; *t*, tongue (= elongated fused glossae). [*R. J. T. del.*

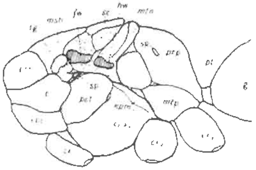
well-developed; *mesepisternum* usually broad, sometimes with a distinct piece in front of it called the *prepectus* (figs. T5, 6, *pct*) lying beneath the tegula and behind the pronotal side-lobe; mesepimeron usually narrow. Mesosternum well-developed, sometimes divided by a median groove or *sulcus*. *Metathorax* distinct and fairly well developed in the oldest groups, but usually shortened, the metanotum very short, compressed close up to or even partly beneath the mesoscutellum; metapleura undivided. *Propodeum* (first abdominal segment, but dealt with here for convenience) short in the oldest groups, but often greatly enlarged and very convex in the higher (figs. T5, 6), closely attached to metathorax. A pair of *spiracles* (sp_1) lie a little below the axillae of the forewings, and a second pair (sp_2) on the sides of the propodeum. *Legs*

always well-developed, all three pairs generally similar; coxae usually short, sometimes elongated; trochanters small, either simple or divided more or less distinctly into two segments (fig. T7); femora stout, some-



a

FIG. T4. Lateral view of alitrunk of *Pergo dorsalis* Leach, fam. Tenthredinidae. Lettering as in fig. T6.
[R. J. T. del.



b

FIG. T5. Lateral view of alitrunk of *Calopompilius defensor* Sm., fam. Psammocharidae. Lettering as in fig. T6.
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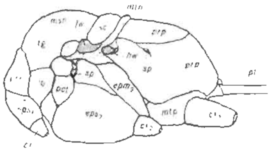


6

FIG. T6. Lateral view of alitrunk of *Sceliphron lactum* Sm., fam. Sphecidae; *cx*, coxa; *epm*, epimeron; *eps*, episternum; *fw*, forewing; *g*, gaster; *hw*, hindwing; *lb*, lobe of prothorax; *msn*, mesonotum; *mtn*, metanotum; *mtp*, metapleuron; *pct*, prepectus; *prn*, pronotum; *prp*, propodeum; *pt*, petiole; *sc*, scutellum; *sp*, spiracle; *tg*, tegula.
[R. J. T. del.

times clubbed distally or basally; tibiae slender, often thickened distally, frequently with a pair of apical spurs; tarsi usually with five segments, (reduced to 4 or 3 in some parasitic forms), the first usually much longer than the others; last segment with a pair of strong claws and an empodium.

W i n g s (fig. T9) folded in repose flat along back of abdomen, one above the other, never held roof-wise. Forewing larger than hind, and connected with it in flight by a more or less extensive series of tiny hooks or *hamuli* (*ham*) situated on the costa of the hindwing so as to engage the recurved posterior margin of the forewing at or before the end of *1A*. Membrane of wings very strong, glassy. *Venation* remarkably modified, both main veins and cross-veins usually very strongly formed, arranged so as to divide the wing into a limited number of closed cells of irregular shape and rather large size. Forewing frequently with a well-developed pterostigma (*pt*) of hardened chitin; hindwing with or without a distinct, folded, anal lobe. The venational scheme, so different from that of all other insects, received its own special notation from Jurine more than a hundred years ago, and this is still in general use by systematists of the Order. More recently the Comstock-Needham Notation has been applied by MacGillivray, but with great difficulty,

owing to the failure of the pupal tracheation to offer reliable evidence. This writer has compared the venation of the Order in minute detail with that of the Dipterous family Bombyliidae, and his hypothesis assumes a closely parallel line of evolution between the two, for which,

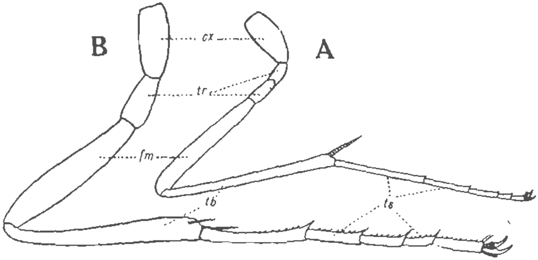


FIG. T7. A, hind leg of an Ichneumon, *Paniscus productus* Brullé, fam. Ichneumonidae; B, hind leg of a Sphecoid Wasp, *Sceliphron laetum* Sm., fam Sphecidae; *cx*, coxa; *fm*, femur; *tb*, tibia; *tr*, trochanter; *ts*, tarsus. [*R. J. T. del.*

however, not a single shred of evidence is forthcoming. This interpretation, given in the second column of the Table on p. 258, has led to such a complicated notation for certain of the main veins that it has proved unwieldy in practice. Only very recently the wings of the ancestors of the Order have come to light in the Lower Permian of Kansas, so beautifully preserved that the whole of the homologies of the veins at once become clear and of the utmost simplicity. Three genera of these Protohymenoptera occur, one with fore and hindwings *in situ*. The stiff glassiness of the membrane of these wings is most marked, as is also the strong formation of the pterostigma.

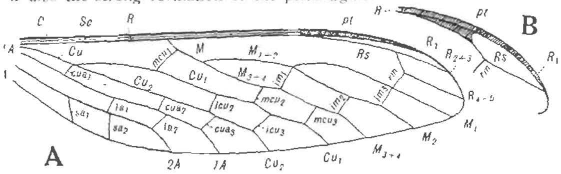


FIG. T8. A, forewing of *Protohymen permianus* Till. Length 11 mm.; B, pterostigma and apex of forewing of *Permohymen schucherti* Till. Order Protohymenoptera, Lower Permian of Kansas. Lettering as in Table on p. 258, New Notation, except R_{2+3}, R_{4+5}, branches of *Rs*, and some additional cross-veins. [*R. J. T. del.*

Fig. T8A shows the forewing of Protohymen permianus Till., while fig. T8B shows the pterostigmatic area of *Permohymen*. The hindwing of the latter was slightly shorter, considerably broader basally, the venation not reduced as in Hymenoptera, and no hamuli present. These wings support the evidence of the early pupal wings of Hymenoptera, in which the main-veins are well-formed but the cross-veins either absent or only faintly indicated (except sometimes, mcu_2 and icu_3); in particular, the absence of rm_1 and rm_2 is mostly striking, these being obviously weak

cross-veins in Jurassic Hymenoptera. The points to notice in the fossil wings are the very narrow costal area, (in which, however *Sc* remains distinct), the encroachment of the pterostigmatic thickening in *Permohymen* as far as *Rs*, the apical position of the reduced *Rs*, (still present

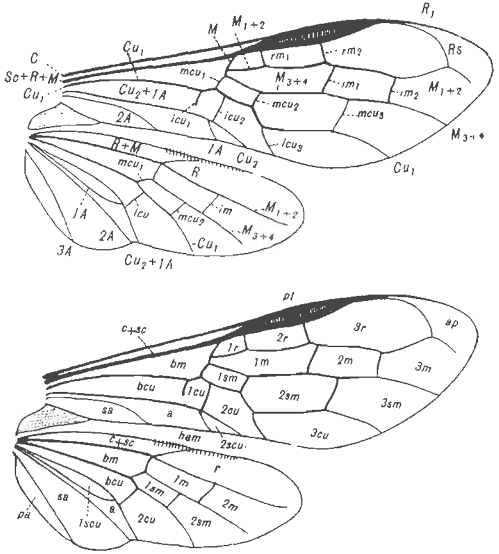


FIG. T9. Wings of *Sirex juvencus* L., male, New Zealand (introd.), fam. Siricidae. A, to show veins; B, to show cells, etc. Lettering as in Table on p. 258, New Notation; except *ham*, hamuli. [*R. J. T. del.*

in *Sirex*), the three-branched condition of *M*, retained only in the Xyelidae (not Australian), the already strong development of mcu_1, the unbranched Cu_1, and the generalized anal area bordered by a separate Cu_2 and with two anal veins; also the general Mecopteroid arrangement of the cross-veins. From this condition the Hymenopterous venation evolved (1) by reduction of hindwing (as in Plectoptera) with consequent specialization of anal area of forewing, Cu_2 fusing with *1A* and the posterior margin becoming straight, (2) by fusion of M_1 with remnant of *Rs* distally, and usually partial or nearly complete reduction of M_2, and (3) by addition of one or two cross-veins (rm_1, rm_2) below pterostigma, and gradual switching, in higher types, of the attachment of M_{1+2} from its original base, first to rm_1, then to rm_2. In the Table on p. 258, the homologies of the veins, cross-veins, and cells are given in full for the New System, the Comstock-Needham System and the Old or Jurinian* System.

*Named in honour of L. Jurine, in whose fine work "Observations sur les ailes des Hyménoptères" (Mem. R. Ac. Sci. Torino, 1820, xxiv, pp.177-214, six

TABLE OF HYMENOPTEROUS WING VENATION

New System. Name.	New System. Notation.	Comstock-Needham Notation. (after MacGillivray).	Old or Jurinian System. Name.
Main Veins:—			
Costa	C	C	Costa
Subcosta	Sc	Sc	—
Principal Vein	$Sc+R+M$ or $R+M$	$Sc+R+M$	Subcostal
Radius	R	R	—
Radial Sector	Rs	R_1	—
Media	M	Rs & M	Cubitus
1st branch	M_1	R_2	Radial
2nd branch	M_2	R_3	—
3rd branch	M_{3+4}	$M+M_{1-2}+M_1+R_{4+5}$	Cubital
Basal piece of M_{1+2}	M_{1+2}	$r\text{-}m$	1st transverse cubital
Cubitus	Cu	Cu	—
1st branch*	Cu_1	$Cu+Cu_1+M_4+M_3+m+M_2$	Median
2nd branch	Cu_2	$1A$	
1st Anal	$1A$	$2A$	Anal
2nd Anal	$2A$	$3A$	Accessory
Cross-veins:—			
1st radio-median	rm_1	Rs (basal piece)	Radial (basal piece)
2nd " "	rm_2	r	—
1st inter-median	im_1	R_5	2nd transverse cubital
2nd " "	im_2	R_4 (including basal piece of M_2)	3rd " "
1st medio-cubital	mcu_1	$m\text{-}cu$	Basal
2nd " "	mcu_2	M_{3+4}	1st Recurrent
3rd " "	mcu_3	M_3	2nd "
1st inter-cubital	icu_1	Cu_1	—
2nd " "	icu_2	Cu_1+M_4	1st transverse
3rd " "	icu_3	M_3	—
Cubito-anal	cua	—	—
			—
Cells:—			
Costal	c	C	Costal
1st subcostal	$1sc$	Sc	—
2nd "	$2sc$	Sc_1	
Pterostigma	pt	pt	Pterostigma
1st Radial	$1r$	R	1st cubital
2nd "	$2r$	1st R_1	1st radial
3rd "	$3r$	2nd R_1	2nd "
Apical	ap	—	Appendiculate
1st Median	$1m$	R_5	2nd cubital
2nd "	$2m$	R_4	3rd "
3rd "	$3m$	R_3	4th "
4th "	$4m$	R_2	—
1st Submedian	$1sm$	M_4	1st discoidal
2nd "	$2sm$	1st M_2	2nd "
3rd "	$3sm$	M_3	1st posterior
Basimedian	bm	M	subcostal
Basicubital	bcu	Cu	median
1st Cubital	$1cu$	Cu_1	3rd discoidal
2nd "	$2cu$	M_2	
3rd "	$3cu$	2nd M_2	2nd posterior
1st Subcubital	$1scu$	1st A	lanceolate (hindwing)
2nd "	$2scu$	1st A	lanceolate (forewing)
Anal	a	2nd A	anal
Subanal	sa	3rd A	—

*That portion of Cu_1 which lies between mcu_1 and icu_2, and is often considerably bent, is known in the Jurinian System as the ***discoidal vein***; the following portion, from icu_2 to mcu_3 is called the ***subdiscoidal vein***. Usually the discoidal vein is considered to run to the wing-margin, i.e., it includes icu_2, and the subdiscoidal vein is then spoken of as arising above, at, or below the middle of the discoidal vein, according to the comparative lengths of icu_2 and the part of Cu_1 basad from it. In the MacGillivray notation the discoidal vein is interpreted as M_2 (to wing-margin) and the subdiscoidal vein as a cross vein m.

Abdomen with ten segments, of which the first (*propodeum* or *median segment*) is attached closely to the thorax (see p. 254). The second segment is normal in the oldest groups, but in all the rest it becomes constricted into a *petiole* or waist. The rest, called the *gaster*,* may have all the segments visible dorsally or the terminal ones may be withdrawn so that only from three to six segments can be seen dorsally, as in the higher groups. Tergites usually strongly chitinized, extending laterally downwards so as partially to overlap the sternites which are also frequently very hard, though sometimes soft and with a median, longitudinal, ventral fold. Abdomen generally smooth and shiny, but very hairy in some wasps and most bees. Male with complex genitalia partly or wholly concealed. The clasping apparatus is formed by the gonocoxites of the ninth segment with their terminal styles; there is also a well developed aedeagus, formed from the penis and its parameres. The tenth segment is much reduced, forming a small proctiger carrying the anus and a pair of short *cerci*, which are sometimes segmented. Female with a complete ovipositor formed from the three pairs of original gonapophyses, one on seg. 8 and two on seg. 9. In the older groups, this ovipositor is used only for its original purpose, and is either a horny process for laying eggs in wood, or developed into saws for cutting open the leaves or stems of plants. In the parasitic groups, it becomes a slender *terebra*, often of great length, for placing the eggs in the host-insect; while in Ants, Wasps and Bees it is developed as a weapon of offence, or *sting*. In each case, the ventral valves of seg. 8 form the actual boring or stabbing organ, and are called the *spiculae*. In the terebra and the sting, they are exceedingly slender, finely toothed or barbed towards their apices; in the Saw-flies, they become specialized as the *saws*, the whole or the greater part of their lower edges being armed with minute teeth or serrated ridges of complex pattern. The inner valves of seg. 9 became the *guide* of the terebra or the *director* of the sting, which is in each case a single grooved organ formed by fusion of the two original gonapophyses; the director is a highly specialized guide furnished with two longitudinal beads in its groove, by means of which the spiculae are held in place. In the Saw-flies these valves remain separate, becoming the *supports* of the saw. The dorsal valves, or gonocoxites of seg. 9, form the outer *sheaths* of the ovipositor or sting, protecting it from injury; in the parasitic groups, they are not developed, leaving the terebra free. *Spiracles* eight pairs in the older groups, placed on the sides of the tergites; the number is reduced in some of the parasitic groups, e.g., in Chalcidoidea, where only two pairs are present, on segs. 1 and 8 respectively. *Malpighian tubules* numerous, this being the only polynephric Order within the Endopterygota.

Life History. The *egg* (fig. T10) is generally elongate oval in shape, not sharply pointed, without sculpture. The *larvae* fall into two distinct types; the phytophagous, caterpillar-like larva of the Saw-flies and allies, and the parasitic or cell-fed grub of the higher groups. The former has a large head with strong mandibles, and usually all three pairs of thoracic legs; in many of the leaf-feeding forms, a series of abdominal prolegs is developed, up to as many as eight pairs; these prolegs are *never* arranged, as in Lepidoptera, on segs. 3-6 and 10 only, and appear to be newly-developed organs rather than the vestiges of true

*This item is used chiefly in the Ants (p. 287), but may conveniently be extended to other groups not having a constriction between gaster and petiole

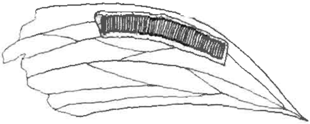


FIG. T10. Eggs of *Perga dorsalis* Leach, *in situ* in leaf of Eucalyptus. Australia. Fam. Tenthredinidae (× 1.1). [*A. Tonnoir del.*

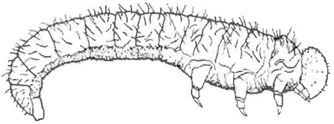


FIG. T11. Larva of *Perga dorsalis* Leach (× 1.4). [*A. Tonnoir del.*

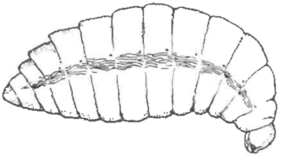


FIG. T12. Larva of *Eumenes latreilli* Sauss. (× 3). Australia. Fam. Eumenidae. [*A. Tonnoir del.*

segmental abdominal appendages. In the higher types the head becomes much reduced, the legs are lost and the larva becomes a whitish or cream-coloured grub. Such grubs feed in one of the following ways:—

1. As an internal parasite in the still living, active host, or in an insect egg. (Ichneumonoidea, Chalcidoidea, Proctotrypoidea, Bethyloidea).
2. As an external parasite on Homoptera (Dryinidae).
3. As a gall-forming parasite of the leaves, buds or stems of plants (Cynipoidea and some Chalcidoidea).
4. As an external parasite, devouring the paralyzed host provided by the mother, either in burrows or closed-up cells (most Vespoidea and Sphecoidea).
5. Living in a nest or cell and fed by adult workers of the species (Formicoidea and Vespidae).
6. Living in a closed cell stored with plant products (honey or bee-bread), (most Apoidea).
7. As a secondary parasite on (3), (4) or (5) (Chrysidoidea, some Chalcidoidea, a few Vespoidea and Apoidea.)

The *pupa* (fig. T13) is a *pupa libera*, usually enclosed in an oval cocoon, spun with coarse, viscous silk from the mouth of the larva. The cocoons of Saw-flies are placed in the soil, singly or in masses; those of the higher groups may be of coarse, pale silk, or brownish and papery in consistency; some forms pupate within the body of the host or in the cell without a cocoon. In some of the Saw-flies the larva undergoes an extra ecdysis within the cocoon, often walling up this shrivelled skin in a separate, closed chamber at the posterior end; it

then appears as a whitish *prepupa* with wing-rudiments, which later on changes to a true pupa by a fresh ecdysis. The total number of instars is variable, but does not exceed six. The imago sheds the delicate pupal covering within the cocoon and cuts its way out with its powerful mandibles. Generally speaking, females are much more abundant than males in this Order; many parasitic types are parthenogenetic for considerable periods, and, in others, the males only live for a short time.

Fig. T13.
Pupa of *Exeirus lateritius* Shuck. (x 2). Australia. Fam. Exeiridae. [*A. Tonnoir del.*

Distribution. The Order is remarkably well represented in Australia by more than 6000 described species, while many more remain to be discovered. The most abundant families are the Encyrtidae (652), Formicidae (627), Eulophidae (587), Thynnidae (438), Hylaeidae (318), Scelionidae (317), Andrenidae (265), Mutillidae (197), Pteromalidae (190), Chalcididae (167), Eumenidae (160), Mymaridae (159), Colletidae (137), and Megachilidae (123). Almost all the principal families are represented, and one, the Megalyridae, is peculiar to Australia. Large and showy species are abundant, especially amongst the Saw-flies and Wasps. In New Zealand the Order is very poorly represented by little over 300 species*; there are no Saw-flies, no Siricidae, only one native Xiphydriid and one Oryssid, no Chrysididae, no Vespoidea except Psammocharidae, and very few Sphecoidea, Ants and Bees.

Fossil History. The Order is abundantly represented in Tertiary strata by forms differing little from those of to-day, ants and bees being fairly numerous. In Mesozoic beds the only known forms are the large Horntails of the genus *Pseudosirex*, from the Upper Jurassic of Bavaria, which closely resembled those of the present day, but had a simpler venation with only a single cross-vein *rm* in the forewing. The geological history of the Order has recently been much more fully unfolded by the discovery of representatives of a new Order, Protohymenoptera (fig. T8) in the Lower Permian of Kansas. It also appears probable that the Upper Carboniferous fossil *Sycopteron symmetricum* Bolton from Commentry, France, belongs to this latter Order. Thus the history of the Hymenoptera can be traced back to the earliest known insect-bearing strata, though the Order itself appears to have been the latest of all to evolve, except perhaps the Lepidoptera.

Economics. Apart from the Saw-flies, (which are highly injurious insects, many of the species doing great damage to fruit trees, forest trees and shrubs), the Cynipoidea and a few Chalcidoidea (which make galls on trees and plants), and a few obnoxious ants and wasps having a taste for fruit and household stores, this Order must be reckoned the most highly beneficial of all Orders of Insects. The unceasing work of the thousands of parasitic Hymenoptera is the principal factor in the maintenance of the balance of insect-life, whereby hosts of injurious species of beetles, flies and moths are prevented from overrunning the world. The study of the life-histories of such forms, and the utilization

*Including undescribed species known to exist in collections.

of their aid in checking introduced pests, is one of the chief hopes of the future for economic biology. Ants, too, on the whole, are highly beneficial in removing and destroying animal and vegetable débris, though some undoubtedly offset this by the fostering care which they lavish on aphids and scale-insects. The Honey Bees supply mankind with the one universally valued insect-food,—*honey*; while bees and flower-wasps are responsible for the fertilization of certain fruit-trees and fodder-crops, as well as of many garden flowers.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order HYMENOPTERA 6249 (311)

Suborder CHALASTROGASTRA 82 (2)

I. TENTHREDINOIDEA 82 (2)
1. Siricidae
2. Xiphydriidae 1 (1)
3. Tenthredinidae 80 (0)
4. Oryssidae 1 (1)

Suborder CLISTOGASTRA 6167 (309)

II. ICHNEUMONOIDEA 310 (107)
5. Megalyridae 19 (0)
6. Stephanidae 7 (0)
7. Evaniidae 70 (2)
8. Ichneumonidae 118 (70)
9. Braconidae 96 (31)
10. Alysiidae 0 (4)

III. CYNIPOIDEA 7 (1)
11. Cynipidae 3 (0)
12. Figitidae 4 (1)

IV. CHALCIDOIDEA 2284 (90)
13. Chalcididae 167 (0)
14. Perilampidae 49 (1)
15. Eucharitidae 48 (2)
16. Callimomidae 86 (2)
17. Agaontidae 9 (0)
18. Eurytomidae 88 (11)
19. Cleonymidae 44 (0)
20. Pteromalidae 190 (20)
21. Encyrtidae 652 (12)
22. Eulophidae 587 (34)
23. Elasmidae 100 (4)
24. Trichogrammatidae 105 (1)
25. Mymaridae 159 (3)

V. PROCTOTRYPOIDEA 527 (45)
26. Belytidae 20 (26)
27. Diapriidae 77 (11)
28. Proctotrypidae 9 (4)
29. Ceraphronidae 84 (0)
30. Scelionidae 317 (2)
31. Platygasteridae 20 (2)

VI. BETHYLOIDEA 97 (2)
32. Bethylidae 38 (2)
33. Dryinidae 59 (0)

VII. CHRYSIDOIDEA 40 (0)
34. Chrysididae 40 (0)

VIII. FORMICOIDEA 627 (18)
35. Formicidae 627 (18)

IX. VESPOIDEA 991 (13)
36. Trigonalidae 3 (0)
37. Psammocharidae 100 (13)
38. Thynnidae 438 (0)
39. Scoliidae 49 (0)
40. Mutillidae 197 (0)
41. Eumenidae 160 (0)
42. Masaridae 22 (0)
43. Vespidae 22 (0)

X. SPHECOIDEA 359 (14)
44. Ampulicidae 10 (0)
45. Exeiridae 1 (0)
46. Stizidae 7 (0)
47. Arpactidae 28 (2)
48. Nyssonidae 44 (0)
49. Nitelidae 4 (0)
50. Larridae 53 (4)
51. Philanthidae 25 (0)
52. Bembecidae 27 (0)
53. Pemphredonidae 21 (0)
54. Trypoxylidae 57 (4)
55. Sphecidae 48 (0)
56. Crabronidae 34 (4)

XI. APOIDEA 925 (19)
57. Colletidae 137 (8)
58. Hylaeidae 318 (8)
59. Andrenidae 265 (3)
60. Nomadidae 1 (0)
61. Melectidae 15 (0)
62. Anthophoridae 17 (0)
63. Megachilidae 123 (0)
64. Xylocopidae 3 (0)
65. Ceratinidae 37 (0)
66. Apidae 9 (0)

The totals for Australian Vespoidea, Sphecoidea and Apoidea have been sup plied by Mr. H. Hacker; that for Australian Formicidea by Mr. J. Clark, Ea Perth, W.A.; those for Australian Chalcidoidea were obtained by adding record species by other authors to Mr. A. A. Girault's totals; the N.Z. census includ a number of undescribed species known to exist in collections.

In classifying Hymenoptera, the chief characters used are the form of the abdomen, the structure of the ovipositor, the details of wing-venation, structure of the pronotum, form of the antennae, mouth-parts trochanters, etc. In the Keys here given, the New Notation is used for venational details, but the corresponding statement in the Old or Jurinian System is added in brackets.

This Order has received much intensive study during the past twenty years, especially in America, and its classification is on the whole very satisfactory. It has appeared necessary to detach the Bethylidae and Dryinidae from the Vespoidea (to which they had recently been removed from their original position in the Proctotrypoidea), and to institute a separate superfamily for them. With this alteration, the Order consists of two Suborders of very unequal extent (cf. Lepidoptera), containing no less than eleven superfamilies and 68 families, 64 of which are represented in Australia, but only 32 in New Zealand.

The two Suborders may be distinguished as follows:—

Second segment of abdomen not constricted to form a waist. Larvae (except Oryssidae) leaf-feeding or wood-boring, with large head and thoracic legs. Suborder CHALASTOGASTRA

Second segment of abdomen constricted to form a waist (petiole). Larva a legless grub, with reduced head. Suborder CLISTOGASTRA

Suborder CHALASTROGASTRA

(SYMPHITA or SESSILIVENTRES)

THIS Suborder contains the Saw-flies and Horntails. It is best regarded as a single superfamily, the Tenthredinoidea, containing several distinct families, only four of which are found in Australia and New Zealand; these may be distinguished as follows:—

1. Fore tibiae with only a single apical spur. 2
   Fore tibiae with two apical spurs. 3
2. No neck present; forewing with basal piece of *M* bent back in line with *mcu*. Fam. 1. SIRICIDAE
   A well developed neck present; forewing with basal piece of *M* normal in position. Fam. 2. XIPHYDRIIDAE
3. Forewing with 2-3 median (3-4 cubital) cells; antennae normally placed. Fam. 3. TENTHREDINIDAE
   Forewing with only one median cell (two cubital cells); antennae inserted well below level of eyes, close to mandibles. Fam. 4. ORYSSIDAE

Superfamily I. TENTHREDINOIDEA.

Family 1. **Siricidae** (Horntails) [Aus. 0, N.Z. 0]. Wings long and narrow; forewing with a short *Sc* sometimes present, basal piece of *M* bent back in line with *mcu*; abdomen cylindrical; female with ovipositor in the form of a hard terebra shaped like a short, blunt needle, and formed of two slender spiculae enclosed in a tight sheath. Larvae wood-borers, with the thoracic legs present but small and imperfectly formed. This interesting family, to which the earliest known fossil Hymenoptera (Upper Jurassic) are closely related, is only represented by the introduced *Sirex juvencus* L. (fig. T9), a handsome insect of very

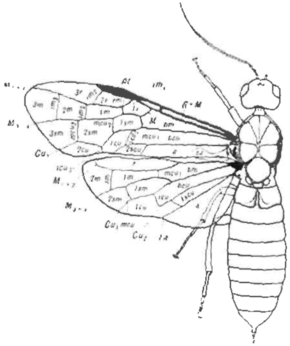


FIG. T14. *Xiphydria decepta* Sm., female, New Zealand, fam. Xiphydriidae. Lettering as in Table on p. 258. [*E. S. Gourlay del.*

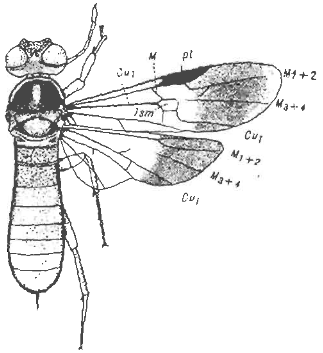


FIG. T15. *Ophrynopus schauinslandi* Ashm., female, New Zealand, fam. Oryssidae. Lettering as in Table on p. 255. New Notation. [*E. S. Gourlay del.*

variable size and with the two sexes very differently coloured. Its larva bores into pine wood, attacking both freshly felled timber and also old logs, but not healthy, growing trees. This species is spreading rapidly in New Zealand, where it is viewed with considerable alarm by foresters and saw-millers.

Family 2. **Xiphydriidae** [Aus. 1, N.Z. 1]. Closely allied to the Siricidae, but differing in the long neck, and normal condition of the basal piece of *M* in forewing; *Sc* always absent. The genus *Xiphydria* is represented by one

species, *X. obtusiventris* Rohw. in North Queensland, and a second, *X. decepta* Sm. (fig. T14) from New Zealand; the latter is almost entirely orange in colour, with hyaline wings. Both are very rare insects.

Family 3. **Tenthredinidae** (Saw-flies) [Aus. 80, N.Z. 0]. More or less stout-bodied, thickset insects with very complete venation (fig. T1); the female has a stout ovipositor in which the spiculae are developed into a pair of saw-toothed instruments for cutting into the tissues of the leaves of plants, the eggs being inserted either singly or in numbers in each cut (fig. T10). The larvae are mostly leaf-feeders; their thoracic legs are well developed, and abdominal prolegs are often present also. Many of them resemble Lepidopterous caterpillars, but can be distinguished by having only a single eye-element on each side of the head, and by the prolegs, when present, having no circlets of crochets, and one pair being on seg. 5. Apart from three small genera of Arginae (*Antargidium*, *Zenarge* and *Trichorrachus*) which shows some affinity with Holarctic forms, the Australian Saw-flies form a very distinct group belonging to the subfamily Cimbicinae, whose nearest relatives appear to exist in South America The dominant genus is *Perga*, with more than 30 species; their larvae (fig. T11) live in masses on eucalyptus leaves, and often entirely strip a young tree of its foliage; these larvae have no abdominal prolegs, and, when disturbed, they raise their bodies into the air, and emit a nauseating odour suggestive of impure eucalyptus oil. When full-fed, they descend to the ground and travel together in a huge mass until some suitable spot is found, when they go underground and spin their hard, silken cocoons together in large clusters. The genus is peculiar in having antennae more or less clubbed, maxillary palpi with only four segments, labial palpi with three. *Perga dorsalis* Leach (pl. 20, fig. 1) is one of the finest and also one of the commonest species; *P. lewisi* Wwd. is a smaller yellowish-brown species; *P. cameroni* Wwd. is peculiar in having rather long, slender antennae, and *P. castanea* Kby. has hairy patches on the wings. The closely allied genus *Xyloperga* only differs in having the normal number of six segments in the maxillary palpi and four in the labial palpi; it contains eleven species. *Pterygophorus* is a very distinct and beautiful genus with eleven species, in which the males have flabellate antennae and the larvae have seven pairs of abdominal prolegs and a long pointed tail; *P. cinctus* Klug (pl. 21, fig. 1) and *P. interruptus* Klug are the best known species, and are often found, replete with honey, on garden flowers. *Philomastix* contains two handsome species with 13-15 antennal segments; *Ph. macleayi* Wwd. (pl. 21, fig. 2) is fairly common. *Phylacteophaga eucalypti* Frogg. is a small, dark-coloured saw-fly, whose larva feeds in the tissues of eucalyptus leaves, forming a blister within which it pupates. *Diphamorphos* contains two small, black species whose dark, velvety larvae are found feeding on dead leaves, under bark, etc.; they much resemble Lepidopterous caterpillars, but have six pairs of prolegs. *Eurys*, *Neoeurys* and *Clarissa* contain a number of small species, the first two metallic in colouring, and found mostly in Tasmania, South and Western Australia, the last-named dull-coloured species mostly from N. Queensland.

The Pear-slug, or larva of the introduced European Saw-fly, *Caliroa limacina* de Geer, is a serious pest on the foliage of pears, cherries and plums in New Zealand, Tasmania and the cooler parts of Australia; it also feeds freely on hawthorn. An attempt is being made in New Zealand to control this pest by the introduction of the Ichneumon-fly *Perilissus luteolator* Grav. from England.

Family 4. **Oryssidae** [Aus. 1, N.Z. 1]. A small family, distinguished by the peculiar venation, which is much less complete than in the true Saw-flies, and by the form of the ovipositor, which much resembles that of the Cynipoidea, with a long, slender terebra; the peculiar position of the antennae is also noteworthy. The larvae are parasitic on those of wood-boring beetles. The only genus represented is *Ophrynopus*, of which a single species, *O. sericatus* Mocs., is found in N. Queensland, while the closely allied *O. schauinslandi* Ashm. (fig. T15) occurs sparingly in New Zealand and the Chatham Islands.

Suborder CLISTOGASTRA

(APOCRITA or PETIOLATA)

This immense Suborder comprises the great majority of species within the Hymenoptera, all being readily recognized by the constriction of the true second abdominal segment to form a waist or petiole behind the propodeum or median

segment. The larva is always a legless grub. The Suborder contains nine Superfamilies, distinguished by the following Key:—

1. Ovipositor issuing from ventral surface of abdomen, usually well before the tip. 2
   Ovipositor or sting issuing from tip of abdomen. 4
2. Forewing with well developed pterostigma (rarely slender or linear), venation usually well-developed; antennae usually with more than 16 segments; trochanters always distinctly two-segmented; abdomen generally soft ventrally, with a longitudinal median fold. II. ICHNEUMONOIDEA
   Forewing without a pterostigma; venation very incomplete; antennae usually with not more than 16 segments; trochanters variable; abdomen without a longitudinal fold; mostly very small insects. 3
3. Sides of pronotum extending back to tegulae; antennae not elbowed; trochanters with a single segment. III. CYNIPOIDEA
   Sides of pronotum not extending back to tegulae; antennae more or less distinctly elbowed (except in Mymaridae); trochanters small, frequently more or less distinctly divided into two segments. IV. CHALCIDOIDEA
4. Abdomen with seg. 2 (and sometimes seg. 3 also) constricted off from the remainder to form a small, distinct nodule or petiole. VIII. FORMICOIDEA
   Abdomen with seg. 2 not constricted off from rest. 5
5. Medium to large, brilliantly metallic forms, with sides of pronotum not extending back to tegulae; hindwing without any closed cells, and with a strong anal lobe separated from rest of wing by a deep cleft; abdomen with only three visible dorsal segments; ovipositor tubular and retractile. VII. CHRYSIDOIDEA
   Not such insects. 6
6. Small to minute, parasitic forms (rarely up to 6 mm.); forewing with no closed median cells (with at most a single closed cubital cell), often with venation greatly reduced or entirely absent; hindwing with at most a single basal cell, viz., the basimedian (subcostal). 7
   Medium to large forms, (very rarely under 5 mm.), mostly predatory or nectar-feeding (a few parasitic); forewing with venation complete or nearly so, having at least one closed median cell (two closed cubital cells); hindwing with two basal cells, viz., *bm* and *bcu* (subcostal and median) (open or incompletely closed in Mutillidae), and usually with two veins extending distally from them. 8
7. Fore femora either greatly swollen or strongly clubbed basally; hindwing with a small but distinct anal lobe, well separated from rest of wing. VI. BETHYLOIDEA
   Fore femora either not swollen, or only clubbed distally; hindwing without an anal lobe. V. PROCTOTRYPOIDEA
8. Sides of pronotum reaching back to tegulae. IX. VESPOIDEA
   Pronotum shortened, more or less collar-like, with its sides not reaching back to tegulae. 9
9. Hairs on body simple or only twisted; hind tarsi slender, with seg. 1 of normal form. X. SPHECOIDEA
   Hairs on body mostly branched or feathered; hind tarsi with seg. 1 enlarged, usually densely haired. XI. APOIDEA

Superfamily II. ICHNEUMONOIDEA.

This group contains the Ichneumon-flies and their allies, including the Long-tailed Wasps, which are peculiar to Australia. The venation (figs. T16-19) of the forewing is fairly complete, with pterostigma present; but *Sc* is absent, the base of *M* is fully aligned with mcu_1, and very often the succeeding piece of *M* is missing; this leads to forms in which mcu_2 becomes aligned with the succeeding piece of *M*; the distal stump of the missing piece, if present, is called the *ramellus*. Further, the cross-vein rm_1 may become aligned with M_{1+2}, the basal piece of the latter vein being eliminated. The ovipositor issues ventrally from the abdomen well before the tip, and the trochanters are divided into two segments. The species are usually of slender, graceful build. The larvae are all parasitic, a very large number of them on Lepidopterous, Dipterous and Saw-fly

larvae which live in the open. Some species have very long ovipositors with which they bore into wood or soil to reach larvae living therein; a few are ant-like and destitute of wings. Six families are known, of which five occur in Australia, four in New Zealand.

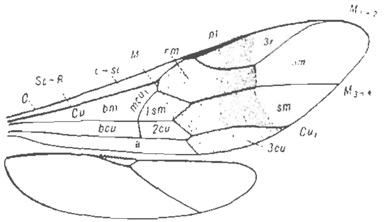


FIG. T16. Wings of *Megalyra fasciipennis* Wwd., Australia. Fam. Megalyridae. Lettering as in Table on p. 258. [*R. J. T. del.*

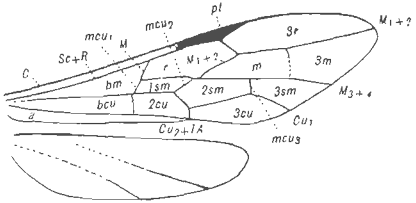


FIG. T17. Wings of *Odontaulacus albosignatus* Kieff., Australia. Fam. Evaniidae, subfam. Aulacinae. Lettering as in Table on p. 258. [*R. J. T. del.*

They can be separated as follows:—

1. A distinct but narrow membranous space between costa and $R+M$. 2
   $R+M$ entirely fused with costa. 4
2. Rather stout-bodied insects with very slight petiolation; the alitrunk about as long as the gaster; ovipositor of enormous length. Fam. 5. MEGALYRIDAE
   Not such insects. 3
3. Antennae very slender, with 30 or more segments; petiole inserted normally on propodeum. Fam. 6. STEPHANIDAE
   Antennae with only 12-14 segments; petiole inserted abnormally, i.e., high up above the hind coxae. Fam. 7. EVANIIDAE
4. Mandibles abnormal, long and with their cutting edges reversed, facing laterally outwards instead of inwards, and not meeting when the jaws are closed. Fam. 10. ALYSIIDAE
   Mandibles normal. 5
5. Forewing with mcu_2 and mcu_3 present (two recurrent veins). Fam. 8. ICHNEUMONIDAE
   Forewing with only mcu_2 present (a single recurrent vein). Fam. 9. BRACONIDAE

Family 5. **Megalyridae** (Long-tailed Wasps) [Aus. 19, N.Z. 0]. This small but remarkable family contains only the purely Australian genus *Megalyra*. The larvae are parasitic in those of Longicorn beetles; it may be assumed, though not yet observed, that the female uses her long ovipositor for boring into wood

to reach her prey. *Megalyra fasciipennis* Wwd. (pl. 20, fig. 2, and fig. T16) is the best known species.

Family 6. **Stephanidae** [Aus. 7, N.Z. 0]. Slender insects with the abdomen more or less clubbed distally, hind tibiae swollen, venation more or less reduced, ovipositor very long; antennae very slender, with 30 or more segments; males much smaller than females. The genera represented in Australia are *Stephanus*, *Hemistephanus*, *Parastephanellus* and *Stenophasmus*. *Stephanus* contains large species, one of the finest being *S. crassicauda* Morl. (pl. 21, fig. 3) from Queensland.

Family 7. **Evaniidae** [Aus. 70, N.Z. 2]. This family is recognized by the abnormally inserted petiole, which is placed high up above the level of the hind coxae; the venation varies from the primitive, fairly complete type found in the Aulacinae (fig. T17) down to forms with only a thickened $R+M$ and pterostigma, but in all cases a costal cell is present in forewing above $R+M$. The primitive subfamily Aulacinae is represented in Australia by small, slender species of the genera *Pristaulacus* and *Odontaulacus*. The Evaniinae include more robust species with thickened veins. The genus *Evania* is represented by about 20 Australian species in which the small gaster has a very slender petiole and is enlarged into a laterally flattened club distally, appearing like a small appendage of the large, stout alitrunk. *E. appendigaster* L. and *E. longigena* Schlett. are both well-known species. *Hyptiogaster macronyx* Schlett. (pl. 21, fig. 4) is a fine, dark brown species. The genus *Gasteruption* (*Foenus*) contains more than 30 Australian species, but only one, *G. crassipes* Sm., in New Zealand. *Pseudofoenus* is a genus peculiar to New Zealand, *Ps. pedunculatus* Schlett. being very common. The larvae of this family are parasitic on the larvae of Longicorn beetles, and also in the egg-capsules of cockroaches and Mantidae.

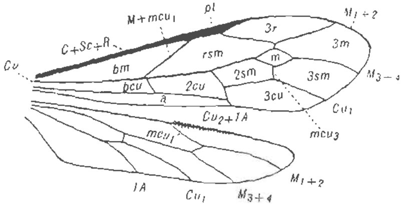


FIG. T18. Wings of *Metopius unifenestratus* Morl. Australia. Fam. Ichneumonidae. Lettering as in Table on p. 258.
[*R. J. T. del.*

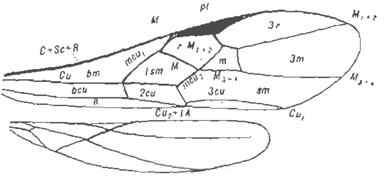


FIG. T19. Wings of *Syngaster lapida* Brullé Australia. Fam. Braconidae. Lettering as in Table on p. 258.
[*R. J. T. del.*

Family 8. **Ichneumonidae** (Ichneumon-flies) [Aus. 118, N.Z. 70]. This enormous family and the next two differ from previous ones in having an apparently thickened costa, due to fusion of $R+M$ with the true costa. In the Ichneumonidae only, the distal cell between M and Cu_1 is divided into two by

mcu_2 (fig. T18). The family is represented by a large number of species in both countries, but many of these have not yet been described. Several common introduced species occur, including the well known European species *Bassus laetatorius* Fabr., which parasitizes the larvae of Syrphidae. Most of the species are highly beneficial, as they parasitize Lepidopterous caterpillars.

The Pimplinae are well represented in both countries by some fine species, of which the most striking by far is the huge *Megarhyssus fractinervis* Voll. (pl. 2, fig. 19): it is a rare New Zealand insect, found chiefly in the western rain forests of the South Island. *Lissopimpla semipunctata* Kby. (pl. 21, fig. 5) is a fine, dark-winged species found in both countries (probably introduced into New Zealand). *Echthromorpha intricatoria* Fabr. (pl. 21, fig. 6) is a widespread species, often nearly an inch long, very common in Australia: it has a black body, with red legs and antennae, and the abdomen has two rows of pale yellowish spots. *Exeristes* and *Lissonota* contain some handsome species. In the allied Cryptinae, *Mesostenus albopictus* Sm. is a very common species in both countries; it is somewhat smaller and less stout than *E. intricatoria*, the black abdomen ringed on each segment with creamy-white, and the third quarter of the black antennae white or pale yellow. Several other genera with smaller species are also found, such as *Cryptus, Hemiteles* and *Bathymetis*.

The Ichneumoninae are very abundant in New Zealand, where numerous species of *Ichneumon, Degithina, Probolus* and *Amblyteles* are found; the red and orange *Ichneumon huttoni* Kby. is one of the finest species. In Australia fewer species are known; one of the finest is the black *Ichneumon albopictus* Cam. with a broad red ring round the abdomen. *Ichneumon (Callicphialtes) messer* Grav. has been introduced into New Zealand as an enemy of Codling-moth. The Tryphontinae are represented by species of *Mesoleptus, Tryphon* and a few other genera in New Zealand; the handsomest of the Australian species is the black and yellow-banded *Metopius unifenestratus* Morl. (pl. 20, fig. 3) from Queensland.

The Ophiinae are the most generally noticed subfamily in Australia, and are not uncommon in New Zealand. They are very slender, reddish brown species, often attracted to light at night. The genera *Ophion* and *Paniscus* are found in both countries: other genera found in Australia but not in New Zealand are *Henicospilus, Anomalon* and *Exochilum*. The commonest Australian species are *Henicospilus turneri* Morl., *Paniscus productus* Brullé (pl. 21, fig. 7), *P. testaceus* Grav., and *Exochilum scaposum* Morl.

Pezomachus (Gelis) philpotti Brues is a tiny, wingless species, 2 mm. long, found occasionally in New Zealand.

Family 9. **Braconidae** [Aus. 96, N.Z. 31]. These are very similar to Ichneumonidae, but have the distal cell between *M* and Cu_1 undivided (i.e., mcu_2 absent) (fig. T19). Most of the species are smaller than those of the previous family, but there are several fine species in Australia. By far the largest and handsomest is the rare Australian species *Trachypetus clavatus* Guer. (pl. 20, fig. 4), occasionally found near Sydney. A number of handsome species of fair size occur in Queensland; *Syngaster lapida* Brullé, 10 mm. long, has a red head, darkly clouded wings, and cream and black abdomen; several species of *Cremnops* have wings broadly banded with fuscous, as in *C. dissimilis* R. Turn. (pl. 21, fig. 8); *Cyanopterus rufus* Szepl. is a handsome species, 8 mm. long, with black head, orange thorax, and wings orange and black; *Acanthodoryctes morleyi* Frogg. measuring up to 10 mm., has an orange head, brownish wings, and a rather stout abdomen.

Most of the species are considerably smaller than the above; the known Australian forms are placed in more than twenty genera, while only about ten genera have so far been recognized in New Zealand. Genera common to both countries are *Meteorus, Rhogas* and *Bracon*. *Schauinslandica* is an interesting genus of the subfamily Helconinae with one species in New Zealand and three in the Chatham Is., where also *Doryctomorpha antipodum* Ashm. occurs. The Vipioninae, sometimes treated as a separate family because of their undivided mesothorax (a character also found in Stephanidae and Alysiidae) are represented in Australia by a number of species of *Vipio, Iphaulax* and *Apanteles*. *I. rubriceps* Frogg. and allied species parasitize the larvae of Longicorn beetles. *Metaspathius apterus* Brues is a tiny wingless species (2 mm. long) found in New Zealand; it belongs to the subfamily Spathiinae. *Microbracon, Leptospathius, Orgtoneura, Parahelcon* and *Westwoodiella* are all genera peculiar to Australia, while *Fhogra* occurs only in New Zealand.

Like the true Ichneumon-flies, the Braconidae are mostly beneficial insects, their larvae being parasitic chiefly on Lepidopterous caterpillars. Many species lay a number of eggs on a single host, so that frequently a dead caterpillar may

e seen which is simply a mass of the small white cocoons of Braconids. Other mall species, like *Ephedrus persicae* Frogg., parasitize aphids and scale-insects. ?*criletus leptopsi* Viereck is a useful parasite on the injurious weevils of the genus *Leptops*.

Family 10. **Alysiidae** [Aus. 0, N.Z. 4]. Small species resembling Braconidae and mostly with similar venation, but distinguished by the remarkable

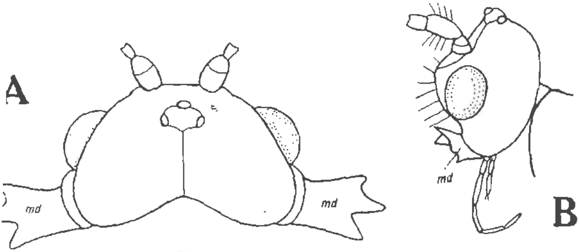


FIG. T20. Head of an undermined Alysiid from New Zealand, showing the abnormal mandibles (*md*): A, dorsal view; B, lateral view. [*R. J. T. del.*

mandibles (fig. T20). The genera *Alysia* and *Asobara* are represented in New Zealand.

Superfamily III. CYNIPOIDEA.

(Gall-wasps).

This group contains only three families, one of which, the Ibaliidae, is very small and not found in Australia or New Zealand. The members of the group are all small insects, mostly from 1 to 4 mm. long, seldom reaching 6 mm.; the

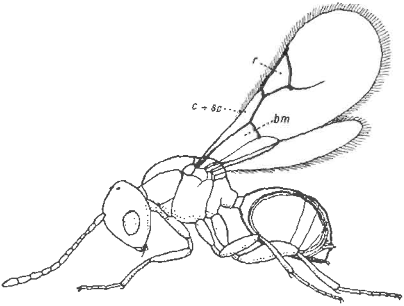


FIG. T21. Lateral view of an undetermined species of Gall-wasp from Brisbane, Australia, fam. Figitidae. Length 1.2 mm. From a cleared mount, showing ovipositor coiled within abdomen. Lettering as in Table on p. 258, New Notation. [*R. J. T. del.*

great majority are gall-forming, but some are either parasitic on the gall-makers, or else inquilines living inside the galls made by others. As a group they may be distinguished from the Chalcidoidea, which they resemble superficially, by the pronotum extending back to the tegulae, the trochanters always small and formed of a single segment, and the antennae never elbowed. The venation is reduced, the forewing having at the most only five completely closed cells,

viz., *c+sc*, *bm* (*=1r+2r*), *3r* (called the *marginal cell*) and sometimes also a small *1m* (called the *areolet*). There is never a thickened pterostigma, and the hindwing has no anal lobe. The group differs from the Proctotrypoidea in having the ovipositor issuing from the abdomen well before the tip; this organ is beautifully constructed and very mobile, with long, delicate spiculae which can be coiled up and withdrawn into the abdomen; it resembles most closely the ovipositor of the Oryssidae.

The two families here dealt with may be separated as follows:—

> Abdomen with tergites extending laterally downwards so as to enclose and hide from view all the sternites except near apex.
> Fam. 12. FIGITIDAE
>
> Abdomen with tergites normal, not extending downwards; most of the sternites visible. Fam. 11. CYNIPIDAE

Family 11. **Cynipidae** [Aus. 3, N.Z. 0]. In Australia the paucity of species of gall-wasps is in marked contrast with their abundance in other countries; most of the galls found in Australia are made by Coccidae. *Hypodiranchis aphidis* Frogg. was bred from peach aphis, and may therefore be an introduced species. *Eucoela gracilicornis* Cam. and *Aulax hypochaeridis* Kieff. are common introduced species in New Zealand, the latter forming galls in the stems of Cat's Ear (*Hypochaeris radicata*). A few undescribed native species exist in Australian collections.

Family 12. **Figitidae** [Aus. 4, N.Z. 1]. The genus *Anacharis* is represented by a single species in each country (*A. australiensis* Ashm. and *A. zelandica* Ashm.); the other Australian species belong to *Cothonaspis*, *Allotria* and *Trybliographa*. Most of the species parasitize aphids and scale-insects.

Superfamily IV. CHALCIDOIDEA.

This great group contains an enormous number of species throughout the world, but only a fraction of them so far have been described. Chiefly owing to the work of Girault in Queensland, nearly 2,400 species are already known in Australia; in New Zealand, on the other hand, scarcely any native species have so far been described, though there are about 90 undescribed species in various collections.

The group as a whole is characterized by the small size of most of the species, the majority measuring from 0.2 mm. to 5 mm. in length, though a few Chalcididae, Eucharitidae and Perilampidae are fairly large insects, measuring up to 15 mm. The pronotum does not extend back to the tegulae. Except in the peculiar family Mymaridae, the antennae (fig. T22) are elbowed, and have a long scape and usually one or more ring-segments (*r*); these latter are tiny, annular segments which can be found, by careful examination, between the pedicel and the funicle; the funicle itself (*f*) consists of a variable number of narrow cylindrical segments; this in turn may be succeeded by a terminal club (*c*), or the funicle may extend to the apex as an elongated flagellum. The part of the antenna from third segment to apex inclusive is called the *clavola*. The total number of segments varies from 4 to 22, but is rarely more than 13.

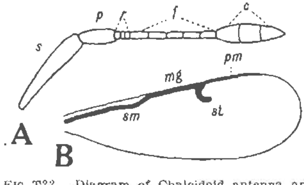


FIG T22. Diagram of Chalcidoid antenna and forewing. A, antenna; c, club; *f*, funicle; p, pedicel; r, ring-segments; s, scape; B, forewing; *mg*, marginal vein; *pm*, post-marginal vein; *sm*, submarginal vein; *st*, stigmatic vein.

The wing-venation has undergone great reduction in all members of the group. Fig. T22B shows diagrammatically a typical Chalcidoid forewing. The stout vein arising from the base and running below the costal margin is termed the

submarginal vein (*sm*); it appears to be actually $R+M$. Further distad, this vein bends and fuses with the costa as far as the pterostigmatic region; this portion is called the marginal vein (*mg*). At the end of the marginal vein there is a fork, the upper branch of which is apparently simply a continuation of the marginal vein, and is called the postmarginal vein (*pm*); while the lower branch passes obliquely downwards in the wing-membrane, and is called the stigmatic vein (*st*). It is seldom that any other veins than these are to be seen; if such are present, they are much slenderer, and are not used in classification. All stages of reduction of the above scheme are found, some forms having no venation at all. The hindwing has either no veins at all, or only a single main vein. Both wings are usually covered with minute hairs, (*discal cilia*), whose arrangement is of considerable importance in classification: in addition, they may carry fringes of longer hairs (*marginal cilia*).

The great majority of species are parasitic forms, some even being secondary parasites on other parasitic Hymenoptera. A considerable number live in galls, either parasitizing the gall-making insects or their larvae, or living as inquilines in the gall. A few have evolved the gall-making habit themselves; they belong chiefly to the Perilampidae, Callimomidae, Erytomidae and Eulophidae. Some minute species parasitize the eggs of other insects. The group is on the whole highly beneficial to mankind; but it must always be remembered that the value of any species depends upon the relationship of its host to man, and that, in the case of special problems, such as the eradication of Prickly Pear in Australia, where the usual order of things is inverted, chalcids may give much trouble, and may even, perhaps, in the end, be the deciding factor against the success of the biological experiment. With these exceptions, it is probably true that the future of the biological control of a large number of insect pests is bound up with the careful study and utilization of members of this group. Those forms especially which parasitize the eggs of injurious insects, such as the Homoptera, may prove of incalculable value to the human race in the future.

The classification of the group is difficult, and the limits of several of the families here given are not accepted by all authors as the same. Sixteen families have been recognized so far in Australia; but of these we shall sink the Miscogasteridae as a subfamily of the Pteromalidae, and the Eupelmidae as a subfamily of the Encyrtidae. Only three families*, the Callimomidae, Eulophidae and Pteromalidae, have so far been recognized by *described* species in New Zealand, but a number of others occur there.

Chalcidoid wasps, except the few large species, should always be mounted entire at the apex of a small triangular slip of cardboard carried on a pin. Students would be well advised not to attempt to describe chance specimens, but only to deal with those whose life-history is known, in so far as they have been bred out from a recognizable host. Girault described most of the immense number of Australian species standing to his name from single specimens obtained by indiscriminate sweeping of grass and herbage, while most of his Trichogrammatidae were picked off window-panes. His types are in the Queensland Museum, Brisbane. The following Key will serve to distinguish the families known to occur in Australia and New Zealand:—

1. Antennae not elbowed, the scape short, ring-segments absent; ovipositor usually arising only slightly before end of abdomen; very minute species having long wing-fringes, hindwing exceedingly narrow, linear, with a long basal stalk, (tarsi with 4-5 segments).
Fam. 25. MYMARIDAE
Antennae distinctly elbowed, scape usually long, ring-segments nearly always present; ovipositor arising well before end of abdomen; except in some Trichogrammatidae, wing-fringes not long and hindwing not linear or basally stalked. 2
2. Females with elongate head, deeply grooved longitudinally above; males wingless, with short antennae having only 3-9 segments, and with middle legs slender or aborted. Fam. 17. AGAONTIDAE
Not such insects. 3
3. Tarsi with 3 segments (very minute species).
Fam. 24. TRICHOGRAMMATIDAE
Tarsi with 4-5 segments. 4
4. Fore tibiae armed with a strong, curved spur; tarsi almost always 5-segmented. 5
Fore tibiae armed with a weak, usually straight, spur; tarsi almost always 4-segmented. 12

*See footnote to page 276.

5. Hind femora greatly swollen, often toothed or spiny beneath; hind tibiae strongly bent. Fam. 13. CHALCIDIDAE
Hind femora not as above; hind tibiae more or less straight. 6
6. Thorax very strongly developed, highly arched, usually deeply punctate. 7
Thorax not as above (if arched, then not exceptionally enlarged as compared with head and after-body). 8
7. Mandibles sickle-shaped, with 1-2 teeth on inner margin; gaster with first segment very large, enclosing all the rest. Fam. 15. EUCHARITIDAE
Mandibles not sickle-shaped, but with 2-3 apical teeth; gaster with first two segments enlarged. Fam. 14. PERILAMPIDAE
8. Hind coxae five or six times as large as fore, either triangularly compressed or with a sharp edge. Fam. 16. CALLIMOMIDAE
Hind coxae not as above. 9
9. Pronotum large. 10
Pronotum small. 11
10. Pronotum square or rectangular. Fam. 18. EURYTOMIDAE
Pronotum lengthened, conical, narrowed in front. Fam. 19. CLEONYMIDAE
11. Middle tibiae long, formed for jumping, with a long or strongly formed, stout spur. Fam. 21. ENCYRTIDAE
Middle tibiae normal. Fam. 20. PTEROMALIDAE
12. Hind coxae large and broad, hind femora flatly compressed, tarsi very long. Fam. 23. ELASMIDAE
Hind coxae and femora normal, tarsi normal. Fam. 22. EULOPHIDAE

Family 13. **Chalcididae** [Aus. 167, N.Z. 0]. A well-marked family, easily recognizable by the greatly swollen hind femora, mostly denticulate beneath, and the strongly bent hind tibiae. Four subfamilies are here recognized, of which the Leucospidinae are considered by some authors to be deserving of family rank; the Chalcodectinae are annectent to the Cleonymidae, and the Podagriinae to the Callimomidae.

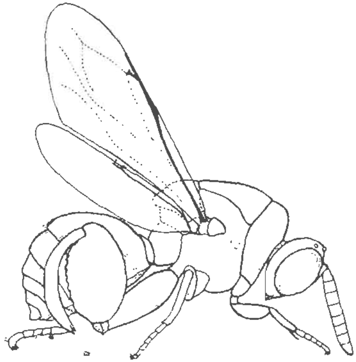


FIG. T23. *Brachymeria aurea* Gir., female, Australia, fam. Chalcididae. Length of body 6.5 mm. [*R. J. T. del.*

The Leucospidinae are large, handsome species with the forewings folded longitudinally when at rest and the ovipositor curled up dorsally over the abdomen; they superficially resemble wasps of the Section Diploptera. *Exoclaenoides cinctus* Gir. (pl. 21, fig. 9) is a fine black and red species, about 14 mm. long.

The Chalcidinae are stoutly built species with robust, rugose or punctate thorax and ovipositor mostly short, not projecting. The principal Australian genera are *Brachymeria** and *Stomatoceras*. None of the species are under 2 mm. and most of them are over 4 mm. in length. *Brachymeria aurea* Gir. (fig. T23) is blackish, with thick golden hairs on thorax and distal half of abdomen, the legs reddish brown; it parasitizes caterpillars of *Delias* (fam. Pieridae). *B. hercules* Gir. measures up to 8 mm. long.

The Chalcodectinae, placed by Ashmead in the Cleonymidae, closely resemble the preceding subfamily, but have the pronotum shaped as in Cleonymidae. They are almost confined to Australian and South America. Twenty Australian species are known, of which the best known belong to *Euchrysia*, *Agamerion*, *Agamerionella* and *Systolomorphella*.

The Podagriinae, placed by Ashmead in the Callimomidae, are distinguished by their more slender build, less robust thorax and excessively long, straight, slender and backwardly projecting ovipositor; they are parasites in the egg-capsules of Mantidae. Twenty Australian species are known, of which more than half belong to the widespread genus *Podagrion*; *Podagrionella* and *Pachytomoides* are genera peculiar to Australia.

Family 14. **Perilampidae** [Aus. 49, N.Z. 1]. Mostly metallic, strongly sculptured species with very large, arched thorax, but hind coxae and femora normal; mandibles with 2-3 apical teeth, not falcate; antennae short, with 12-13 segments; gaster mostly sessile, often triangular, with first two segments large. The dominant genus in Australia is *Perilampus*, of which 15 species are known. *Perilampoides bicolor* Gir. makes small, round, isolated galls on the leaves of Eucalypts. Several species of *Trichilogaster* make galls on the twigs and flower-stalks of wattles (*Acacia*). Many of the species are parasitic in the larvae of Lepidoptera and Neuroptera.

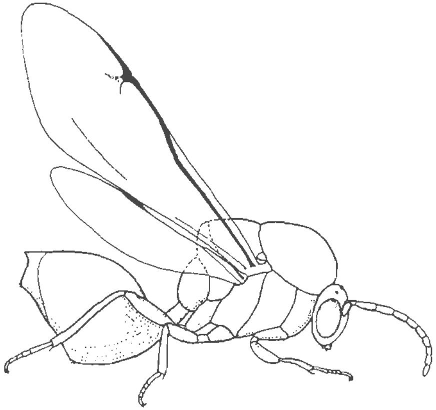


FIG. T24. *Metagea rufiventris* Ashm., female, Australia, fam Eucharitidae. Length of body 9 mm. [*R. J. T. del.*

Family 15. **Eucharitidae**† [Aus. 48, N.Z. 2]. Closely related to the preceding family, but distinguished by the falcate mandibles with 1-2 teeth on inner margin, the gaster with first segment enormously developed, hiding all the rest,

*All the Australian species hitherto placed in *Chalcis* Fabr. belong to *Brachymeria* Wwd.; see Gahan & Fagan, Smiths. Inst. Bull. No. 124, 1923, pp.24, 31.

†Greek *eucharis* graceful, stem *eucharit-*, hence fam. Eucharitidae, not Eucharidae.

and often laterally flattened; hind coxae and femora slender; thorax enormous humped or strongly arched; scutellum often armed with spines or processes; antennae with 10-22 segments. Mostly metallic species with rugose thorax; parasitic in the nests of ants. The principal Australian genera are *Eucharis, Psilogaster Rhipipallus* and *Stilbula;* the last-named contains some handsome species 5-6 mm long having the scutellum armed with two long processes and the petiole long and slender. *Metagea rufiventris* Ashm. (fig. T24), 9 mm. long, with metallic green thorax and reddish brown abdomen, is a parasite in the nests of Bull-dog Ants (genus *Myrmecia*).

Family 16. **Callimomidae (Torymidae)** [Aus. 86, N.Z. 2]. Thorax not robust, but prothorax strongly developed; hind coxae very large, either with a sharp edge or triquetral in form; mostly metallic green, blue or golden species, with antennae having 11-13 segments. There are three very distinct subfamilies. The Callimominae are gall-forming species ranging from under 1 mm. to about 3 mm. in length and having the sexes similar; *Macrodontomerus* and *Callimome* (*Torymus*) are the chief genera found in Australia; a single species, *C. antipodum* Kby., has been recorded from New Zealand. The Megastigminae are distinguished by having only a single spur on hind tibiae; they are parasitic in galls. *Megastigmus* and *Neomegastigmus* are both well represented in Australia.

The Idarninae are a remarkable group in which the males are wingless, with the antennae short (sometimes reduced to as little as 3 segments), and differ greatly in form from the slenderer and more elongated females, which have normal antennae with 10-13 segments, and a long ovipositor. Like the next family, they live in figs. *Philotrypesis* and *Sycoryctes* are the chief Australian genera; both sexes of *S. australis* Frogg. have been well figured by Froggatt (Australian Insects, pl. xii, figs. 9-11).

Family 17. **Agaontidae* (Blastophagidae)** [Aus. 9, N.Z. 0]. A highly specialized family of fig-dwelling insects, with striking differences between the sexes; females with very elongate head, longitudinally grooved above, the antennae with a long scape and 9-13 segments; males blind, wingless, with soft

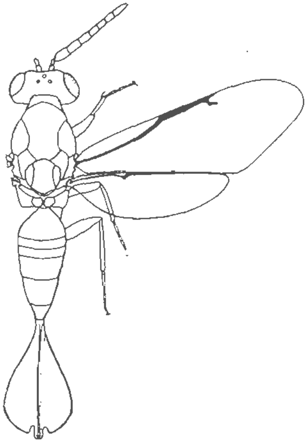


FIG. T25. *Dinoura auriventris* Ashm., female. Australia, fam. *Cleonymidae*. Length 7 mm. [*E. S. Gourlay del.*

*Greek *agomai*, to wonder at, stem *agaont-*, hence fam. Agaontidae, not Agaonidae.

integument, greatly reduced antennae, and middle legs either very small, weak and slender, or entirely absent; these males live inside native figs, and superficially resemble tiny Termites. *Pleistodontes imperialis* Saund. and *P. froggatti* Mayr are found in the fruit of the Moreton Bay Fig (*Ficus macrophylla*). The European *Blastophaga psenes* L. has been successfully introduced into parts of Australia in connection with the cultivating of the Smyrna fig.

Family 18. **Eurytomidae** [Aus. 88, N.Z. 11]. Pronotum strongly developed, square or rectangular; legs strong, hind tibiae with two spurs; antennae with 9-13 segments. Most of the species belong to the dominant genus *Eurytoma**, mostly black in colour, sometimes with greyish or whitish pubescence; they measure 2-4 mm. in length and are reared from galls. *E. acaciae* Cam. infests the seeds of *Acacia decurrens* in both countries; *E. picus* Gir. lives in channels under the bark of Eucalypts. The genus *Harmolita* (= *Isosoma*) contains a number of injurious gall-forming species. The introduced North American *Bruchophagus funebris* How. infests clover and lucerne seed.

Family 19. **Cleonymidae** [Aus. 44, N.Z. 0]. Prothorax strongly developed but narrowed in front; hind tibiae with two spurs; antennae with 9-13 segments. The most remarkable of the Australian genera are *Thaumasura* and *Dinoura*. *T. terebrator* Wwd. is a slender, metallic purple species 6 mm. long, with long ovipositor; *T. rubrofemoralis* Ashm. is 10 mm. long, with bronze-green thorax and blue abdomen. *Dinoura* has a three-flanged ovipositor like an elongate propeller; the female of *D. auriventris* Ashm. (fig. T25) is 7 mm. long, with golden-green abdomen, that of *D. cyanea* Ashm. is 10 mm. long, with blue head and thorax, and basal half of abdomen yellow; the males are much smaller and more normally shaped. Other genera found in Australia are *Tomocera* and *Platygerrhus*.

Family 20. **Pteromalidae** [Aus. 190, N.Z. 20]. Closely allied to the preceding family, from which it differs chiefly in the small prothorax; mesopleura with a distinct groove, fore tibiae with strong spur, middle tibiae with short spur. The subfamily Pteromalinae has only a single spur on the hind tibiae; the genus *Pteromalus* is represented in both countries. Girault has made a large number of

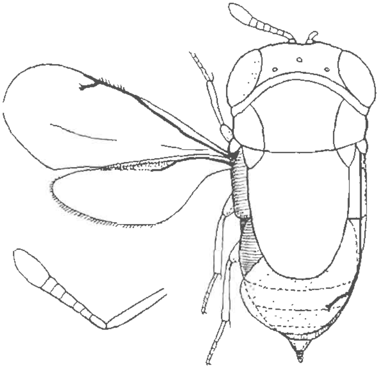


FIG. T26. *Scutellista cyanea* Mot., female, Australia, fam. Pteromalidae. Length 1.3 mm. Below, antenna, lateral view. [*R. J. T. del.*

Australian genera containing two or three species each. *Scutellista cyanea* Mot. (fig. T26) is a stoutly built species of a deep metallic purple colour which parasitizes *Lecanium oleae* in Australia and other countries; when at rest the

**Eurytoma olearíae* Mask. (N.Z.) is a platygasterid, see p. 284.

wings are partially covered by the huge scutellum. The species of *Coelocyba* are reared from galls on Eucalypts. *Mormoniella* (*Nasonia*) *brevicornis* Ashm. parasitizes sheep-fly maggots and pupae (Calliphorinae). Attempts have been made to utilize it, both in Australia and New Zealand, for the control of these pests, but so far without much success. *Spalangia nigra* Latr. is a wide-spread parasite of the House-fly.

The Miscogasterinae, considered by some authors as a distinct family, only differ in having the hind tibiae with two spurs. More than 50 Australian species are known, the principal genera being *Miscogaster*, *Systasis*, *Lamprotatus* and *Arthrolysis*. *Decatomothorax gallicola* Ashm. is a stoutly built, brownish species reared from galls of the Kurrajong Tree.

Family 21. **Encyrtidae** [Aus. 652. N.Z. 12]. Antennae with 8-12 segments (six only in a few forms); pronotum very short; scutellum usually large. Middle legs developed for jumping, the tibia widened distally and armed with a long, thick spur; gaster sessile. In this huge family we include the Eupelminae, considered by some authors as a distinct family, but only differing from the rest of the Encyrtidae by the presence of parapsidal furrows on the mesonotum. Most of the species are small, 1-2 mm. long. In the Encyrtinae the principal genera are *Encyrtus* and *Aphycus*; *A. lounsberyi* How. (fig. T27) is a valuable

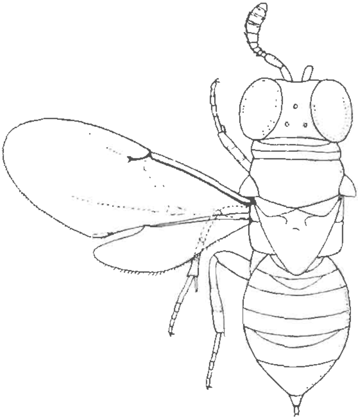


FIG. T27. *Aphycus lounsberyi* How., female, Australia, fam. Encyrtidae. Length 1.1 mm. [*R. J. T. del.*

parasite on *Lecanium oleae* and has considerably reduced the ravages of this scale in citrus orchards around Sydney; it has also been introduced into California. *Tachinophagus australiensis* Gir. parasitizes sheep-fly maggots (Calliphorinae) in Queensland. *Encyrtus flavus* How. is an introduced parasite of *Coccus hesperidum*, *E. inquisitor* How. an introduced parasite of Mealy-bugs of the genus *Pseudococcus*; both of these are found in New Zealand. The Ectrominae are abundant in Australia, the principal genera being *Coccidoxenus*, *Epidenocarsis* and *Anagyrus*; *Fulgoridicida* is important economically, its six species parasitizing the eggs of plant-hoppers in Queensland. The Signiphorinae contain ten Australian species of the peculiar genus *Signiphora*, under 1 mm. long, with 6-segmented antennae. In the Eupelminae, more than 40 Australian species of *Eupelmus* are recorded, also one from New Zealand (*E. messene* Walk.). The family is of great economic importance, as most of the species are parasites of scale-insects and aphids. An attempt is at present being made in New Zealand to introduce from America

Habrolepis dalmanni Wwd. (originally a European species) the only known parasite of the Oak Scale (*Asterolecanium variolosum* Ratz.) which is causing most serious damage to British Oaks (*Quercus robur*) around Christchurch.

Family 22. **Eulophidae** [Aus. 587, N.Z. 34]. Antennae mostly with few segments; forewings with *mg* mostly longer than *sm*; fore tibiae with a short, thin and usually straight spur; middle tibiae not formed for jumping; tarsi 4-segmented (except in some Aphelininae). There are five subfamilies, Aphelininae, Eulophinae, Elachertinae, Entedinae and Tetrastichinae. Of these the Aphelininae have considerable affinity with the previous family, notably in their being parasites of scale-insects, in their general build, and their ability to jump, although the middle tarsi are not specialized as in true Encyrtidae. The most abundant genera are *Coccophagus*, *Aphelinus*, *Physcus* and *Ablerus*. The North American species *Aphelinus mali* Hald., recently introduced into New Zealand as a natural control for Woolly Aphis on apple-trees, has increased to such an extent that this pest has been almost eliminated from the principal orchard districts; it has also been introduced from New Zealand into Australia.

The Tetrastichinae are well represented in Australia, the principal genera being *Melittobia*, *Aprostocetus*, *Tetrastichus* and *Ootetrastichus*. The last-named genus contains small species parasitic in the eggs of Homoptera; *O. beatus* Perk. is a Queensland species parasitic in the eggs of the Sugar-cane Hopper (*Perkinsiella saccharicida* Kirk.) and has been introduced into the Hawaiian Islands with excellent results. *Rhicnopeltella eucalypti* Gahan (subfam. Elachertinae) forms

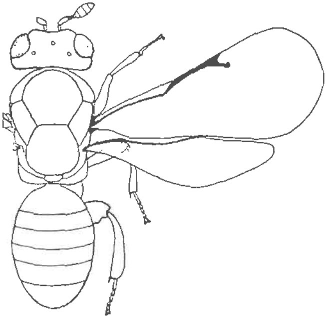


FIG. T28. *Rhicnopeltella eucalypti* Gahan, female, Australia and N.Z. (introd.), fam. Eulophidae. Length 1.8 mm. [*E. S. Gourlay del.*

galls on the twigs and leaves of the Tasmanian Blue-gum (*Eucalyptus globulus*), and is doing great damage to plantations in New Zealand. *Zagrammasomoides fasciatus* Gir. of the same subfamily makes globular, green galls on the leaves of Bloodwood (*Eucalyptus corymbosa*). *Entedon metallicus* Nees (= *Pleurotropus epigonus* Walk.) has been introduced into New Zealand as a parasite of the Hessian-fly.

Girault has made over 100 genera to contain the numerous Australian species of this family, but most of them only contain one or two species apiece.

Family 23. **Elasmidae** [Aus. 100, N.Z. 4]. A small family only differing from the previous one in the large, strongly compressed hind coxae and thick, flatly compressed hind femora; tibiae and tarsi slender, the latter very long; antennae with 9-10 segments. Nearly all the species belong to the widespread genus *Elasmus*, in which the antennae of the males are branched; they are small, blackish species, mostly about 2 mm. long. *Euryischia lestophoni* How. is a parasite on the flies of the genus *Cryptochaetum* (*Lestophonus*) which are parasites of the Cottony-cushion Scale (*Icerya purchasi* Mask.).

Family 24. **Trichogrammatidae** [Aus. 105, N.Z. 1]. Tarsi with only 3 segments; antennae with at most 8 segments including a single ring-segment; hindwings narrow, sometimes linear and with long fringe. The species are all small, often under 1 mm. long, usually yellowish or brownish in colour, and chiefly parasitic in the eggs of various insects, or on thrips and leaf-hoppers. The principal Australian genera are *Oligosita*, *Ufens*, *Aphelinoidea*, *Pterygogramma*

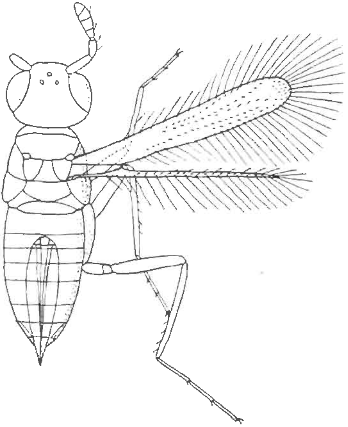


FIG. T29. *Austromicron zygopterorum* n.g. et sp., female, Australia, fam. Trichogrammatidae. Length 0.6 mm. [*R. J. T. del.*

and *Trichogramma*. *Austromicron zygopterorum** n.g. et. sp. (fig. T29) is parasitic in the eggs of damsel-flies around Sydney; it can swim, dive and fly with vigour. *Trichogramma pretiosa* Riley has been recorded as a parasite of Codling-moth at Auckland, N.Z.

Family 25. **Mymaridae** (Fairy-flies) [Aus. 159, N.Z. 3]. Antennae not elbowed, at most with 13 segments, and without ring-segments; wings narrow, more or less stalked basally, with long marginal cilia; venation obsolete; legs long and thin, tarsi with 4-5 segments; ovipositor arising usually from near end of abdomen; very minute species, mostly black, with yellow markings; all parasitic in the eggs of other insects.

This interesting family was formerly associated with the Proctotrypoidea; but, as the ovipositor does not actually issue from the end of the abdomen, and the prothorax does not reach back to the tegulae, its natural place is within the Chalcidoidea. About half the Australian species belong to the genera *Polynema* and

*Genus AUSTROMICRON n.g. (fig. T29):—Allied to *Prestwichia* Lubb. and *Centrobiella* Gir., but differing from both in having the gaster short and broadly sessile, the ovipositor shorter and much less protruded; it also differs from *Prestwichia* in having both sexes fully winged, the forewing with narrower disc carrying fewer but more distinct lines of cilia, the hindwing with only one line of discal cilia, the eyes larger; from *Centrobiella* it also differs in having the antennae inserted at the level of the lower third of the eyes (as in *Prestwichia*), the forewing much narrower, the marginal cilia much longer. *Genotype*:—*Austromicron zygopterorum* n.sp.; total length, female 0.6 mm., male 0.5 mm.; medium brown, with black eyes, gaster of male dark brown; other characters as shown in fig. T29. *Habitat*:—National Park, N.S.W., bred from eggs of Zygopterous Dragonflies, Nov. 20th-30th, 1915 and March 23rd-Apr. 6th, 1916. *Types*:—Holotype female, allotype male and long series of paratypes in Cawthron Institute Collection, Nelson, N.Z. My thanks are due to Mr. P. H. Timberlake of Honolulu for assistance in placing this genus.

Gonatocerus; the largest species, *G. spinozai* Gir., is 1.8 mm. long. Other Australian genera are *Stethynium*, *Anagrus*, *Paranagrus*, *Anaphes* and *Alaptus*; the last-named contains the smallest known Australian Hymenopteron, *A. newtoni*

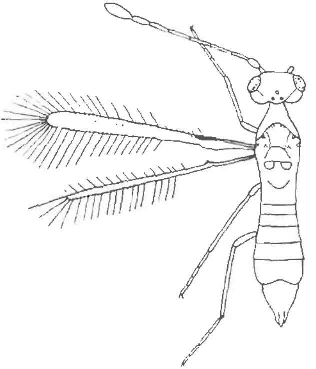


FIG. T30. *Paranagrus optabilis* Perk., female, Australia, fam. Mymaridae Length 0.75 mm. (after Perkins).

Gir., 0.25 mm. long. *Paranagrus optabilis* Perk. (fig. T30) parasitizes the eggs of the Sugar-cane Hopper (*Perkinsiella saccharacida* Kirk.) and has been successfully introduced into the Hawaiian Islands for the control of this pest.

Superfamily V. PROCTOTRYPOIDEA (SERPHOIDEA)*.

The members of this group are all parasitic species, mostly of small size: *they can be at once distinguished from the Cynipoidea and Chalcidoidea by the* fact that the ovipositor, which is usually more or less tubular, with fine, hair-like spiculae, issues from the extreme end of the abdomen; they also differ from the Chalcidoidea in having the sides of the pronotum extending back to the tegulae. Most of them have the venation greatly reduced, as in the previous superfamily, but some of the more primitive forms (Belytidae) may have the forewings with a closed *bm* and *r*, and sometimes a closed *1sm* also (*cf.* Bethyloidea, figs. T36, 37); the hindwing seldom has any clear venation, rarely a single closed cell (*bm*). The names given to these closed cells by systematists in the group are the *basal* (*bm*), *radial* (*r*) and *submedian* (*1sm*). The antennae may be either elbowed or straight, but seldom have any ring-segments. The great majority of the species are beneficial as the larvae live inside the eggs or larvae of other insects, particularly Orthoptera, Hemiptera, Coleoptera, Lepidoptera and Diptera.

The two families Bethylidae and Dryinidae, for a long time included within this group, do not rightly belong here, and are transferred to a new superfamily. This leaves only seven recognized families, one of which, the Heloridae, is not found in the Southern Hemisphere. The other six all occur in Australia, and probably also in New Zealand, if searched for. More than 500 species are known from Australia, less than 50 from New Zealand. The families may be distinguished by the following Key, in which, owing to the presence of a num-

*The generic name *Serphus* Schrank, 1780 has priority over *Proctotrupes* Latr., 1796, but the latter (or its variant, *Proctotrypes*) has been in use for such a long time without challenge that it has a good claim to be considered a *nomen conservandum*. If we also take into consideration the endless confusion that would be caused in teaching by using the terms Serphidae and Serphoidea, which are *undistinguishable in pronunciation* from the well-established Syrphidae and Syrphoidea in the Order Diptera, this claim becomes greatly strengthened. For these reasons, the names Proctotrypidae and Proctotrypoidea are retained in this book.

ber of wingless forms in Australia and New Zealand, characters other than those taken from the wing-venation are given precedence:—

1. Gaster with sharp lateral keels or margins. 2
   Gaster without lateral keels. 3
2. Forewing with submarginal, marginal and stigmatic veins present; antennae usually 12-segmented in both sexes (rarely 11, or less), labial palpi with two or more segments. Fam. 30. SCELIONIDAE
   Forewing without venation, or at most with submarginal vein and a pterostigma only; antennae 10-segmented (rarely 8-9); labial palpi with only one segment. Fam. 31. PLATYGASTERIDAE
3. Antennae inserted near the mouth. Fam. 29. CERAPHRONIDAE
   Antennae inserted well above the mouth. 4
4. Mandibles without teeth; forewings with a closed costal cell and strong pterostigma. Fam. 28. PROCTOTRYPIDAE
   Mandibles with teeth; forewings with marginal vein linear, without pterostigma. 5
5. Labial palpi 3-segmented; fore and often hind wings with a distinct *bm*, forewing also usually with a closed *r*; antennae with 14-15 segments. Fam. 26. BELYTIDAE
   Labial palpi 2-segmented; neither fore nor hind wing with a closed *bm*; *r* of forewing either absent or incomplete; antennae with 11-14 segments. Fam. 27. DIAPRIIDAE

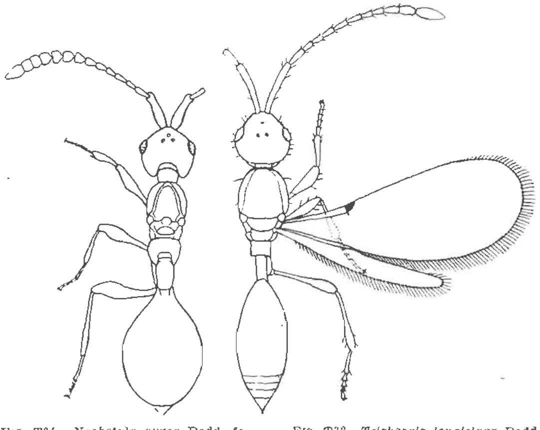


FIG. T31. *Neobetyla aurea* Dodd, female, Australia. Fam. Belytidae. Length 2.5 mm. [*E. S. Gourlay del.*

FIG. T32. *Trichopria longiclava* Dodd, female, Australia. Fam. Diapriidae. Length 2 mm. [*R. J. T. del.*

Family 26. **Belytidae** [Aus. 20, N.Z. 26]. Judging by the number of palpal segments, insertion of antennae, wing-venation and generalized form of gaster, this is the most archaic family of the group. Antennae inserted on a frontal prominence, in males 14-segmented, in females with 14-15 segments; labial palpi with 3 segments; forewing with *bm* present, also usually a closed radial cell (*r*); hindwing often with *bm* present also. The genera *Stylaclista*, *Aclistoides*, *Pantolytomyia* and *Psilomella* are peculiar to Australia. A group of wingless,

brown, ant-like species about 2 mm. long includes *Neobetyla aurea* Dodd (fig. T31) from North Queensland and the two New Zealand species *Parabetyla spinosa* Brues and *Betyla fulva* Cam.; the last-named is probably synonymous with *Tanyzonus bolitophilae* Marsh., bred from the New Zealand Glow-worm (a Mycetophilid larva). *Probetyla subaptera* Brues is a New Zealand species with vestigial wings. These are all rare insects, mostly found at high altitudes.

Family 27. **Diapriidae** [Aus. 77, N.Z. 11]. Closely related to the previous family, but distinguished from it at once by the reduction in the wing-venation and the number of palpal segments. Antennae inserted on a frontal prominence, in males with 12-14, in females with 11-13 segments. Only three of the known New Zealand species have so far been described, viz., *Diapria coccophaga* Mask., *Malvina punctata* Cam. and *Spilomicrus quadriceps* Sm. The last-named genus is represented also by twelve species in Australia; *S. nigriventris* Dodd, from North Queensland, is 2 mm. long, shiny black, with dark reddish femora clubbed distally. *Hoplopria* has thirteen species in Australia; *Hemilexis* and *Trichopria* (fig. T32) three each. *Neurogalesus, Euhoplopria, Cardiopria, Solenopiella, Leaiopria* and *Polydiapria* are peculiar to Australia. *Antarctopria latigaster* Brues is a wingless species found under stones on Macquarie Island.

Family 28. **Proctotrypidae* (Serphidae)** [Aus. 9, N.Z. 4]. A small family, remarkable for its mandibles having no teeth; the antennae are 13-

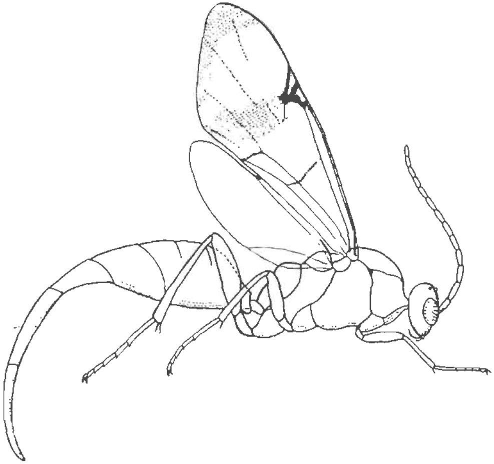


FIG. T33. *Proctotrypes* (*Serphus*) *maculipennis* Cam., female, New Zealand, fam. Proctotrypidae. Length 10 mm [*R. J. T. del.*

segmented in both sexes, with one ring-segment. Of the Australian species, seven belong to *Proctotrypes* (*Serphus*), one to *Disogmus* and one to the very peculiar genus *Acanthoserphus* (*A. albicoxa* Dodd). The New Zealand species all belong to *Proctotrypes*, the finest being *P. maculipennis* Cam. (fig. T33), shining reddish brown, with transparent yellow wings darkly shaded below the stigma.

Family 29. **Ceraphronidae** [Aus. 84, N.Z. 0]. Minute insects (under 2 mm. long) distinguished by the antennae with 9-11 segments, inserted close to the mouth, coupled with the normally shaped, unkeeled gaster. Forewings

*See footnote on p. 280.

always with a marginal vein from base to pterostigma, and also a stigmatic vein a swollen pterostigma is also present: hindwing without venation. The Australia species have mostly been described by Alan Dodd from North Queensland. O these, nearly 50 belong to the genus *Ceraphron*, more than a dozen to *Conostigmu* while *Megaspilus*, *Dendrocerus* and *Aphanogmus* are all fairly well representec *Ceraphron erythrothorax* Dodd, 1.5 mm. long, is blackish with a red thora: There are no genera peculiar to Australia, but *Pseudoceraphron* is confined t Lord Howe Island. *Lygocerus niger* How. is an introduced species parasitic o Cabbage Aphis (*Aphis brassicae* L.) both in Australia and New Zealand.

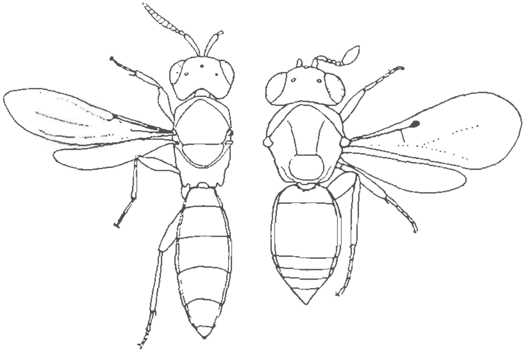


FIG T34. *Scelio punctaticeps* Dodd, female, Australia. Fam. Scelionidae. Lengt of body, 4 mm. [*E. S. Gourlay de*.
FIG. T35. *Aphanomerus bicolor* Perk., female, Australia. Fam. Platygasteridae Length of body, 1.6 mm. (after Perkins).

Family 30. **Scelionidae** [Aus. 317, N.Z. 2]. This is the dominant famil of the group, the species being recognized at once by the laterally keelec gaster, coupled with the presence of the stigmatic vein of the forewing; th submarginal, marginal and postmarginal veins are also usually present. Antenna elbowed, usually clubbed and with 11-12 segments in female, (rarely 7-segmented) in the males not clubbed, 12-segmented (10 only in *Scelio*). All the species ar egg-parasites, and many are of great economic importance. Only two specie are known from New Zealand, viz., *Hoplogryon novae-zealandiae* Brues, 1 mm long, with short wings, and *Paragryon casteneus* Brues, 2 mm. long, wingless both are rare insects, found only at high altitudes. In contrast with this is th rich Australian fauna of this family. The widespread genus *Scelio* (fig. T34 contains about 30 Australian species, of which *S. australis* Frogg. and *S. ovi* Gir parasitic in the eggs of *Locusta*, are the best known. *S. chortoicetes* Frogg. an *S. fulgidus* Crawford parasitize the eggs of the inland plague-locusts of th genus *Chortoicetes*. Other genera with numerous Australian species are *Hoplo teleia*, *Macroteleia*, *Plastogryon*, *Baryconus*, *Telenomus*, *Ceratobaeus*, *Acolus Hoplogryon* and *Hadronotus*. The last-named is parasitic in eggs of Hemiptera Genera with fewer species, but peculiar to Australia, are *Neoscelio*, *Encyrtoscelio Mirotelenomus*, *Gryonella*, *Acolomorpha*, *Ceratobaeoides*, *Mirobaeus*, *Mirobaeoides* and *Phanuromyia*.

Family 31. **Platygasteridae** [Aus. 20, N.Z. 2]. Closely related to th previous family, with which it agrees in the laterally keeled gaster, bu distinguished from it by the more reduced venation: forewings usually entirel without venation, but at most with a submarginal vein ending in a swollen ptero stigma. Antennae elbowed, clubbed, 10-segmented in both sexes (rarely 8-9). I Australia the principal genus is *Aphanomerus* with eight species; this genus i a connecting link with the sub-family Baeinae of the Scelionidae. *A. bicolo*

Perk. (T35) was bred from eggs of various species of leaf-hopper (Jassidae) in North Queensland. *Platygastoides*, *Miramblyaspis* and *Trichoroides* are genera peculiar to Australia. *Metaclisis olcariae* Mask. is a common New Zealand species which makes galls in various species of *Olearia*; it was described as an *Eurytoma*.

Superfamily VI. BETHYLOIDEA.

The two families Bethylidae and Dryinidae were for many years placed in the Proctotrypoidea, but have more recently been removed to the Vespoidea. Their true position seems to be intermediate between Vespoidea and Proctotrypoidea, and they are best treated as a separate superfamily. They can be at once distinguished by the small size (mostly 1 to 3 mm., rarely up to 8 mm.), the presence of a distinct anal lobe to the hindwing, similar to that of the Chrysidoidea but smaller, though equally well marked off from the rest of the wing, and by the enlargement of the fore femora, which are always either entirely swollen or else strongly clubbed basally (obclavate). The sides of the pronotum extend back to the tegulae in all except a few Dryinidae, which can be at once recognized by the chelate fore tarsi. The venation is more complete than in the Proctotrypoidea,

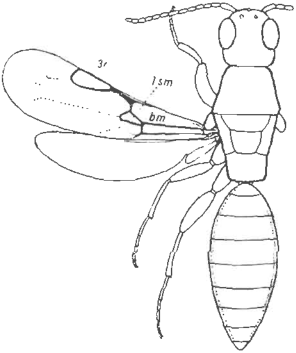


FIG. T36. *Sierola* sp. indet., female. New Zealand. Fam. Bethylidae. Length 3.5 mm. [*E. J. T. del.*

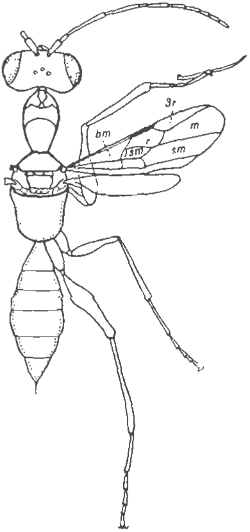


FIG. T37. *Neodryinus raptor* Perk., female, Australia. Fam. Dryinidae. Length 5.5 mm. [*E. S. Gourlay del.*

Lettering as in Table on p. 258, except $m = 1m + 2m + 3m$, $r = 1r + 2r$, $sm = 2sm + 3sm$.

the forewing always having the basimedian cell (*bm*) and frequently also the basi-cubital (*bcu*) complete, and often a closed radial (*r*) also; the stigmatic

vein and pterostigma are usually well developed. The hindwing has no venation. The two families may be distinguished as follows:—

Head oblong or oval; fore tarsi normal; antennae with 12-13 segments, inserted close to mouth. Fam. 32. BETHYLIDAE

Head transverse; fore tarsi with more or less strongly developed chelate claws (except in *Aphelopus*); antennae with ten segments. Fam. 33. DRYINIDAE

Family 32. **Bethylidae** [Aus. 38, N.Z. 2]. The larvae in this family are parasitic in larvae of Lepidoptera, Diptera and Coleoptera. Most of the Australian species have been described by Kieffer from North Queensland, and are included in the genera *Sierola, Eupsenella, Goniozus, Rhabdepyris, Epyris, Prometsitius* and others. The commonest species is *Goniozus antipodum* Wwd., parasitic on the larvae of the Codling-moth and various native leaf-rollers (Tortricites). *Sierola antipodum* Ashm. is a common species parasitic in Cecidomyiid galls on tea-tree (*Leptospermum*). *Ateleopterus longiceps* Ashm., 4 mm. long, shiny black, is probably parasitic on larvae of wood-boring beetles. The New Zealand species belong to the genera *Sierola* (fig. T36) and *Apanesia*.

Family 33. **Dryinidae** [Aus. 59, N.Z. 0]. With the exception of the genus *Aphelopus*, in which the fore tarsi are normal, this family is remarkable for the specialization of the fore tarsi of the females as chelate grasping organs. The fifth segment of the tarsus becomes greatly altered to form one of the chelae, while the other is formed from one of the tarsal claws (fig. T37).

The larvae are parasitic on Homoptera, chiefly leaf-hoppers (Jassidae) and plant-hoppers (Fulgoroidea). *Anteon* is the most abundant genus in Australia, with sixteen species. *Neochelogynus, Paradryinus, Pseudogonatopus, Neodryinus* and *Echthrodelphax* are also well represented. *Neodryinus raptor* Perkins (fig. T37) is a slender black insect, 5 mm. long, with a long prothorax. *Chalcogonatopus, Paragonatopus* and *Epigonatopus* are genera peculiar to Australia. The family is of great economic importance, since any Homopteron parasitized by a Dryinid is unable to produce eggs.

Superfamily VII. CHRYSIDOIDEA

This group consists of one very distinct family, the Chrysididae, whose members are easily recognized at a glance by their brilliant metallic colouring, long tubular and retractile ovipositor, and gaster with only three visible dorsal segments. The pronotum does not extend back to the tegulae; the whole body is very hard

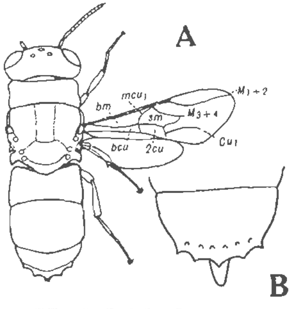


FIG. T38. A. *Pentachrysis imperiosa* Sm., female, Australia. Fam. Chrysididae; B, apex of abdomen, enlarged. Lettering as in Table on p. 258, except sm=1sm+2sm. [*E. S. Gourlay del.*

and generally coarsely sculptured or rugose; the venation is incomplete, there being only one closed radial cell and no closed median cells in the forewing, and no closed cells at all in the hindwing; in the latter, there is a strong anal lobe,

separated from the rest of the wing by a very deep cleft. The larvae are parasitic in the cells of wasps of the groups Vespoidea and Sphecoidea. The group is absent from New Zealand; the Australian species are almost all of them bright metallic green, blue or purple.

Family 34. **Chrysididae** (Cuckoo-wasps, Ruby-wasps, Gold-wasps) [Aus. 40, N.Z. 0]. The great majority of the Australian species belong to the genera (or subgenera) formed from the old wide-spread genus *Chrysis*, principally to *Tetrachrysis* and *Hexachrysis*, distinguished by having the abdomen ending distally in four and six toothed projections respectively. *H. lyncea* Fabr. is an African species which extends through Malaya to Australia, where it is represented by a variety or subspecies *violacea* Sm. *H. tasmanica* Mocs. and *T. verreauxi* Buysson both occur in Tasmania, as also does *Chrysidea reversa* Sm. Most of the species are tropical or subtropical. *Pentachrysis imperiosa* Sm. (fig. T38) is a well-known, metallic blue-green species in Eastern Australia, measuring 7-10 mm. long. The finest of all the Australian species is the large, metallic purple *Stilbum splendidum* Fabr. (pl. 20, fig. 5), measuring up to 18 mm. long; it appears to be only a subspecies of *S. cyanurus* Forst., found in Europe and Africa. Two species of *Heptachrysis* are confined to Western Australia. Other genera represented are *Chrysidea, Holochrysis, Gonochrysis, Monochrysis* and *Trichrysis*.

Superfamily VIII. FORMICOIDEA (HETEROGYNA).
(Ants.)

This group is a well-marked one containing a single family Formicidae, divided into seven subfamilies, all of which are represented in Australia, where more than 600 species are known. They are abundant everywhere, and are certainly the dominant insects on the continent. Though undoubtedly beneficial in the main, owing to their ceaseless activities in removing dead or dying insects from the face of the earth, especially in forest country, yet there are a number of species

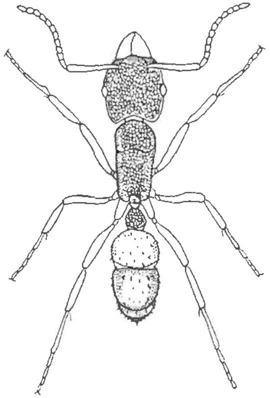


FIG T39. *Chalcoponera metallica* Sm., the Green-head Ant, worker, Australia. Fam. Formicidae, subfam. Ponerinae. Length 6.5 mm. [A. Tonnoir del.

which are pests in houses, gardens and orchards, and others, such as the Bulldog ants (*Myrmecia*), which are very bellicose and bite and sting viciously. In New Zealand, ants are not at all common, and less than twenty species of small size are known, belonging to three subfamilies.

Family 35. **Formicidae** (Ants) [Aus. 627, N.Z. 18]. Distinguished *from all other Hymenoptera by the free part of the abdomen being divided* into a highly mobile *pedicel*, consisting of one or two segments, and a larger, convex terminal portion, called the *gaster*. When the pedicel is formed of a single segment, it is called the *petiole*; if a second segment is present, it is called the *post-petiole*. The petiole is usually in the form of a small node. Antennae always strongly elbowed in females and workers, usually with a long scape and a terminal flagellum or funicle; number of segments from 4 to 13; those of males not elbowed, usually with one more segment than workers and queens, and also often with a short scape. All the species are social insects, almost always with three distinct castes, viz., winged males, fertile females (queens) with wings which are lost after pairing, and sterile females or workers, without wings; in some cases there are specialized workers with large heads and mandibles, known as soldiers; many other forms of male, female and worker have also been recognized in special cases. The workers are usually armed with a powerful sting and strong jaws, but in some cases the sting is aborted (Formicinae, some Dorylinae). The nests are made either in the ground, under logs, stones or rocks, under the bark of trees, in fallen trees or stumps, or, more rarely, in the foliage of trees.

The Ponerinae are the most primitive subfamily, and are especially well

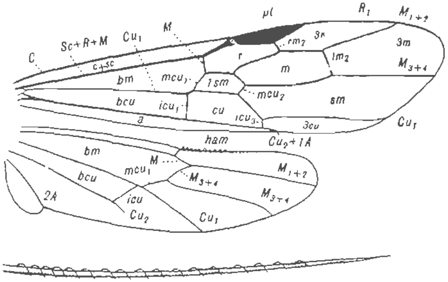


FIG. T40. Wings of *Myrmecia gulosa* Fabr., male, Australia, fam. Formicidae, subfam. Ponerinae. Lettering as in Table on p. 258, except *ham.* hamuli; $cu = 1cu + 2cu$; $m = 1m + 2m$; $r = 1r + 2r$. Below, hamuli, much enlarged. [*R. J. T. del.*

represented in Australia by *137* species placed in *30* genera; they have the pedicel formed of a single segment, but the first segment of the gaster is constricted behind; sting strongly developed; forewings with cells *r* and *m* closed (fig. T40). The pupae are enclosed in cocoons. The genus *Myrmecia*, confined to Australia (*except for a single species in New Caledonia*), *contains the huge Bull-dog Ants* and the smaller Jumpers; the former measure up to an inch in length, and are exceedingly fearless and fierce, and capable of inflicting very painful bites and stings; the latter are also fierce, active species, which swarm out of their nests *and advance to the attack in a series of jumps or springs. Myrmecia gulosa* Fabr. (pl. 21, figs. 17-19), the Red Bull-dog or Soldier Ant, is a very common species in Eastern Australia, dull red, with long yellow mandibles and the apical half of the gaster black; the worker measures 20 mm in length, the queen a full inch *M. forficata Fabr. is a closely allied species, red with black eyes and gaster*; it extends from Victoria to Queensland. *M. tarsata* Sm. and *M. pyriformis* Sm. are large black species; in the former the mandibles are dark red, in the latter pale yellow; these are not so ferocious as the red species, and do not build such large nests. *M. auriventris* Mayr. *is a somewhat rarer and smaller species with* golden abdomen. The best known of the Jumpers is *M. nigrocincta* Sm. (pl. 21, fig. 20), half-an-inch long, black with front and hind parts of thorax and the pedicel reddish-yellow. It forms a fairly large, low, mound-shaped nest in dry

forest country. About forty species of this genus are known altogether. The genus *Chalcoponera* contains a number of Australian species, small, dark ants, 6 mm. or less in length, of which the best known is the Green-head, *C. metallica* Sm. (fig. T39) having the head rugose and thorax of a dark metallic green colour; this species stings severely for its size. The allied genus *Rhytidoponera* contains about twenty Australian species, while *Acanthoponera* is represented by two species in Queensland and one in New Zealand (*A. brouni* Forel). The peculiar, blind ants of the genus *Amblyopone* are confined to Australia, Papua and New Zealand. *Onychomyrmex* is a monotypic genus found only in Australia, while the peculiar Malayan genus *Odontomachus* extends into Australia as far as western New South Wales. Other genera represented in Australia are *Platythyrea, Bothroponera, Euponera, Ponera, Leptogenys* and *Anochetus*. *Ponera antipodum* Forel and *Mesoponera castanea* Mayr are well-known New Zealand species; other genera represented there are *Stigmatomma* and *Discothyrea*.

The small subfamily Cerapachyinae, until recently considered as a tribe of the Ponerinae, is well represented in Australia by about fifty species belonging chiefly to *Phyracaces* and *Eusphinctus*; they are small, slender species, chiefly found in the north.

The Dorylinae are a small subfamily represented in Australia only by three species of *Aenictus*, found in N. Queensland; they have blind workers and females, with vestigial sting and pedicel with only one segment; the males are large, with cell *r* closed but cell *m* open in forewing.

The small subfamily Pseudomyrminae, until recently placed as a tribe of the Myrmecinae, is represented in Australia by five species of the genus *Tetraponera*. They are somewhat intermediate in character between Dorylinae and true Myrmecinae.

The Myrmecinae are a large subfamily in which the pedicel is distinctly two-segmented, the sting present, the gaster usually short, and the male possesses cerci; the pupae are naked. No less than 143 species are recorded from Australia,

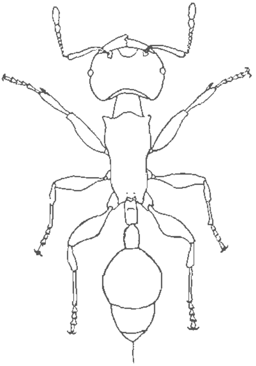


FIG. T41. *Podomyrma gratiosa* Sm., worker, Australia. Fam. Formicidae, subfam. Myrmecinae. Length 8.5 mm. [*E. S. Gourlay del.*

11 from New Zealand. *Podomyrma* contains a number of species found on tree-trunks in Australia, ranging from 3 to 6 mm. in length, with broad heads and short gaster. *P. gratiosa* Sm. (fig. T41) dull reddish with black gaster, is widely distributed throughout the eastern half of Australia. *Monomorium* is found both in Australia and New Zealand, there being nearly twenty species in the former and six in the latter country; *M. antarcticum* Wh., and *M. nitidum* Sm., are both

fairly common species in New Zealand, while *M. rubriceps* Mayr. is a well-known Australian species, about 6 mm. long, red with black tip to gaster. *M. pharaonis* L. is an introduced species of very small size, which is a common pest in houses. There are numerous species of *Pheidole* in Australia, all small ants having soldiers with very large heads; the best known are *Ph. variabilis* Mayr, *Ph. ampla* Forel (W.A.) and *Ph. tasmaniensis* Mayr. *Cremastogaster* is a peculiar genus with heart-shaped gaster; *C. fusca* Meyr., and *C. pallipes* Meyr. are both common species. Other genera found in Australia are *Solenopsis, Metapone, Meranoplus, Dacryon, Epopostruma, Machomyrma* and *Aphaenogaster*. *Orectognathus* and *Strumigenys* occur both in Australia and in New Zealand, while *Huberia* is peculiar to New Zealand.

The Dolichoderinae have the pedicel with a single segment, the sting very small or vestigial, the antennae always 12-segmented, and the pupa always naked. They can be recognized by the peculiar odour of rancid butter (Tapinoma odour) given out from their anal glands. Fifty-seven species are known from Australia, but the group is absent from New Zealand. Of the Australian species the most peculiar belong to the genus *Leptomyrmex*, in the nests of which a queen has never yet been found; these are slender ants which carry the gaster turned up over the back of the thorax. *L. erythrocephalus* Fabr. (pl. 21, fig. 21) is a fairly common species, half-an-inch long, very slender, with long legs and antennae; it is black, with red head and antennae. In Queensland *L. varians* Em. stores honey in the manner of the true honey-pot ants of the Formicinae, certain workers in each nest being filled to repletion with liquid honey so that the gaster is enormously distended; these serve as store-houses for the rest of the colony. This genus is the only known Dolichoderine genus with this habit. *Iridomyrmex* is a wide-spread genus with more than thirty Australian species; the best known, and perhaps the most numerous insect in individuals in the whole of Australia, is the Mound Ant, *I. detectus* Sm., which causes so much annoyance by making its huge mound-nests on garden paths; it is about 8 mm. long, purplish-brown in colour, with reddish head, has a strong tapinoma odour, and

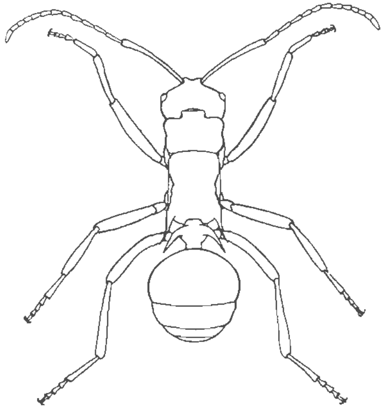


FIG. T42. *Polyrhachis ammon* Fabr., worker. Australia. Fam. Formicidae, subfam. Formicinae. Length 7 mm. [*E. S. Gourlay del.*

bites savagely. This ant may often be seen attending to various scale-insects, and is suspected of helping to spread Indian Wax-scale and other troublesome species. *Iridomyrmex rufoniger* Lowne is a much smaller, black species, which

often invades houses. Other genera represented in Australia are *Dolichoderus* with seven species, *Bothriomyrmex*, *Technomyrmex*, *Turneria* and *Froggattella*, the last-named being monotypic and confined to New South Wales.

The Formicinae (Camponotinae) are highly evolved ants with a single-segmented pedicel, no sting, and no anal glands; the pupae are usually enclosed in cocoons. They are very abundant in Australia, no less than 232 species being known. The genus *Camponotus* is represented by nearly a hundred species in Australia, many of them of large size, almost as big as Bull-dog Ants, but incapable of stinging. *C. intrepidus* Kby. (pl. 21, fig. 22) is a large, black species varying from 12 to 20 mm. in length; it has an enormous head and swollen gaster. Its nests are very conspicuous in the bush, and one variety or subspecies builds a clay or mud chimney to its nest. *C. nigriceps* Sm. is the common large "Sugar-Ant" which is so often a pest in houses; it measures from 10 to 15 mm. in length, and is red, with black head and gaster. The Honey-pot Ants of Central Australia belong to this genus and to the allied *Melophorus*, the species being *C. inflatus* Lubb. (the black honey-ant or "Yarumpa"), *M. cowleyi* Frogg. (the golden-yellow honey-ant or "Ittootoonee") and *M. bagoti* Lubb. (the red honey-ant). The replete workers of *C. inflatus* and *M. cowleyi* measure 17 mm. in length and the gaster is enormously distended. The aborigines esteem

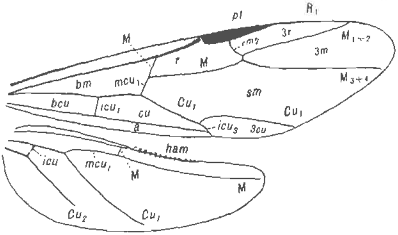


FIG. T43. Wings of *Polyrhachis ammon* Fabr., male, Australia, fam. Formicidae, subfam. Formicinae. Lettering as in Table on p. 258, except *ham*, hamuli; *cu=1cu+2cu*; *r=1r+2r*; *sm=1sm+2sm*. [*R. J. T. del.*

these ants a great luxury and dig out their nests in their search for the honey-pots. *Polyrhachis* is a genus of beautiful harmless ants common everywhere in Australia and remarkable for the spines or processes of the propodeum and pedicel. *P. ammon* Fabr. (figs. T42, 43) is a common species, black, with golden green thorax and golden gaster. *P. femorata* Sm. is black, with reddish brown femora. Both of these are about 7 mm. long. Most of the species nest in logs or under rocks, but there are some smaller species in Queensland which build their nests in trees. The most remarkable of the tree-dwelling ants, however, is the Green Tree-ant, *Oecophylla virescens* Fabr., widely distributed from Africa to Papua and N. Queensland; they sew together a large number of leaves into a large globular nest. Some of the workers line up to hold a leaf in position, while others bring mature larvae, which they squeeze until they exude their silk, and then use them as shuttles for weaving the leaves together. These ants are dark green, slender, only 6 mm. long, but they are very pugnacious and bite viciously. Other genera found in Australia are *Acantholepsis*, *Prenolepsis*, *Notoncus* and *Opisthopis*. The only known New Zealand species of the subfamily is *Melophorus advenus* Sm., but *Prenolepsis longicornis* Latr. is an introduced household pest.

Superfamily IX. VESPOIDEA.

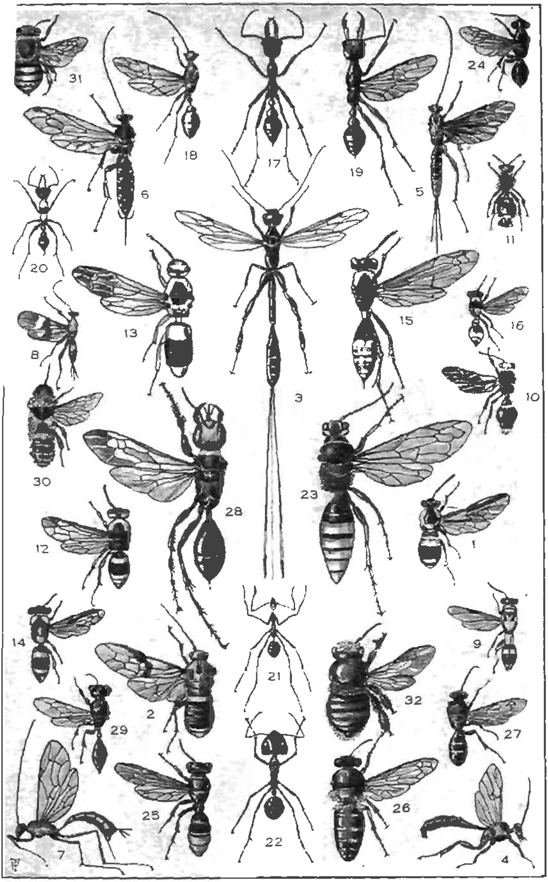
This group and the succeeding one include between them most of the insects commonly known as Wasps, i.e. medium to large, stinging Hymenoptera which are neither Ants nor Bees. The Vespoidea have a true sting issuing from the tip of the abdomen; the trochanters consist of a single segment, except in the anomalous Trigonalidae; the pronotum extends back to the tegulae (distinction from Sphecoidea and Bees); the pedicel is not separated off from the rest of the afterbody as in the Ants; except in the Trigonalidae, the antennae are 13-segmented

PLATE 21

HYMENOPTERA

All figures natural size

1. *Pterygophorus cinctus* Klug (Fam. TENTHREDINIDAE), female.
2. *Philomastix macleayi* Wwd. (Fam. TENTHREDINIDAE), female.
3. *Stephanus crassicauda* Morl. (Fam. STEPHANIDAE), female.
4. *Hyptiogaster macrononyx* Schlett. (Fam. EVANIIDAE), female.
5. *Lissopimpla semipunctata* Kby. (Fam. ICHNEUMONIDAE), female
6. *Echthromorpha intricatoria* Fabr. (Fam. ICHNEUMONIDAE), female
7. *Paniscus productus* Brullé (Fam. ICHNEUMONIDAE), female.
8. *Cremnops dissimilis* R. Turn. (Fam. BRACONIDAE), female.
9. *Exoclaenoides cinctus* Gir. (Fam. CHALCIDIDAE), female.
10. *Ephutomorpha ferruginata* Wwd. (Fam. MUTILLIDAE), male.
11. *Ephutomorpha ferruginata* Wwd. (Fam. MUTILLIDAE), female.
12. *Odynerus mirabilis* Sauss. (Fam. EUMENIDAE), female.
13. *Rhynchium abispoides* M.W. (Fam. EUMENIDAE), male.
14. *Euparagia deceptor* Sm. (Fam. MASARIDAE), female.
15. *Polistes tepidus* Fabr. (Fam. VESPIDAE), female.
16. *Ropalidia socialistica* Sauss. (Fam. VESPIDAE), female.
17. *Myrmecia gulosa* Fabr. (Fam. FORMICIDAE), worker.
18. *Myrmecia gulosa* Fabr. (Fam. FORMICIDAE), male.
19. *Myrmecia gulosa* Fabr. (Fam. FORMICIDAE), female.
20. *Myrmecia nigrocincta* Sm. (Fam. FORMICIDAE), worker.
21. *Leptomyrmex erythrocephalus* Fabr. (Fam. FORMICIDAE), worker.
22. *Camponotus intrepidus* Kby. (Fam. FORMICIDAE), soldier.
23. *Exeirus lateritius* Shuck. (Fam. EXEIRIDAE), male.
24. *Tachytes nigerrimus* Sm. (Fam. LARRIDAE), female, N.Z.
25. *Cerceris froggatti* R. Turn. (Fam. PHILANTHIDAE), female.
26. *Bembex furcata* Er. (Fam. BEMBECIDAE), male.
27. *Pison spinolae* Shuck. (Fam. TRYPOXYLIDAE), female. N.Z.
28. *Chlorion saevum* Sm. (Fam. SPHECIDAE), female.
29. *Rhopalum carbonarium* Sm. (Fam. CRABRONIDAE), female. N.Z.
30. *Gastropsis pubescens* Sm. (Fam. COLLETIDAE), male.
31. *Anthophora pulchra* Sm. (Fam. ANTHOPHORIDAE), fema'e.
32. *Lestis aërata* Sm. (Fam. XYLOCOPIDAE), female.



P. Tillyard del.

HYMENOPTERA

in the males, 12-segmented in the females; the after-body usually has six segments visible dorsally (distinction from Chrysidoidea); the venation is generally very complete, there being one or two closed median cells (two or three closed cubital cells) in the forewing, and (except in the Mutillidae and some Scoliidae) two closed basal cells in the hindwing, i.e. *bm* and *bcu*. In the forewing, cross-vein rm_2 is absent, so that cells *1r* and *2r* form a single cell (fig. T44, *r*). In a number of groups the venation does not reach to the terminal margin of the wing. Some of the families are hunting, predatory wasps, which attack and numb their prey by stinging them in one or more of their nerve-ganglia, and then drag or carry them off to their nests, where they are stored as food for the larvae. In others, the female goes underground and searches for her prey, attacking it *in situ*, and laying one egg on each grub so attacked. The Trigonalidae and Mutillidae are true parasites on other wasps; but this habit would appear to be a secondarily developed one in the case of the Mutillidae. Eight families are known in Australia, with a total of nearly 1,000 species; but only the Psammocharidae are represented in New Zealand. The absence of the other families of Vespoidea from New Zealand is one of the most striking characteristics of the New Zealand Insect Fauna.

Apart from the anomalous Trigonalidae, the group is divisible into two well-marked Sections, the Fossores* (Burrowing or Digging Wasps) and the Diploptera (Solitary and Social Wasps). The families can be distinguished as follows:—

1. Antennae with more than twenty segments; trochanters distinctly divided into two segments. Fam. 36. TRIGONALIDAE
   Antennae 13-segmented in males, 12-segmented in females; trochanters only composed of a single segment. 2
2. Posterior lateral lobes of pronotum always ending either in front of or below tegula; wings never folded longitudinally when at rest. (Section FOSSORES*) 3
   Posterior lateral lobes of pronotum ending above tegula, and always angulated; wings (except in some Masaridae) folded longitudinally when at rest. (Section DIPLOPTERA) 6
3. Hind legs very long; hind tibiae with two apical spurs. Fam. 37. PSAMMOCHARIDAE
   Hind legs of normal length; hind tibiae variable. 4
4. Very hairy forms, with the venation not extending right to the terminal margin of the wings. 5
   Smooth or only slightly hairy forms with the venation extending right to the terminal margin of the wings (females wingless, with thorax divided into three very distinct, subequal parts). Fam. 38. THYNNIDAE
5. Flower-haunting forms, the females winged but capable of burrowing underground; hindwing with one or two closed cells. Fam. 39. SCOLIIDAE
   Ground or tree-trunk haunting forms, the females wingless, underground burrowers; hindwing of male without closed cells. Fam. 40. MUTILLIDAE
6. Tarsal claws simple; social species constructing nests of a papery substance, and having males, females and workers. Fam. 43. VESPIDAE
   Tarsal claws toothed beneath; solitary or only partially social species, without any workers. 7
7. Wings either not folded longitudinally when at rest, or only partially folded. Fam. 42. MASARIDAE
   Wings folded longitudinally when at rest; solitary species. Fam. 41. EUMENIDAE

Family 36. **Trigonalidae** [Aus. 3, N.Z. 0]. This small family appears to be intermediate between the Ichneumonoidea and typical Vespoidea, as it has the divided trochanters and many-segmented antennae of the former, whereas the ovipositor issues from the end of the abdomen, and closely resembles those of the latter, though it does not appear to be known whether it is used as a sting or not. The insects are rare, and only two described species are known from Australia, viz., *Taeniogonalos maculatus* Sm., and *Mimelogonalos bouvieri*

*This term originally included the Sphecoidea also.

Sch., the latter found in Tasmania. A third, undescribed species comes from Stradbroke Is., S. Queensland.

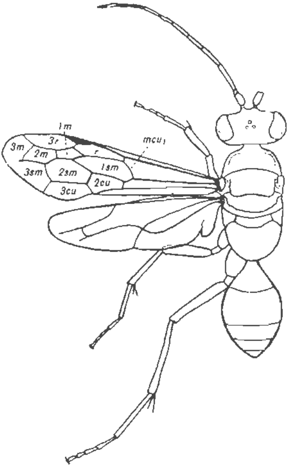


FIG. T44. *Pseudagenia fasciata* Fabr., female. Australia. Fam. Psammocharidae. Length 13 mm. (Dark fasciae on wings omitted.) [*E. S. Gourlay del.*

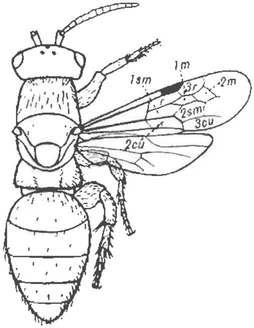


FIG. T45. *Anthobosca lagardei* R. Turn., female. Australia. Fam. Scoliidae, subfam. Anthoboscinae. Length 8 mm. Lettering as in Table on p. 258, New Notation, except $r = 1r + 2r$. [*E. S. Gourlay del.*

Section FOSSORES.

(Digging or Burrowing Wasps).

Family 37. **Psammocharidae (Pompilidae)** (Sand-wasps, Spider-hunters) [Aus. 100, N.Z. 13]. This large family is easily recognized by the long hind-legs, the tibiae of which always have two apical spurs, by the smooth, often shiny body, and by the active, predatory habits, the wasps hunting about on the ground, tree-trunks, etc., searching for spiders, which they attack with great ferocity and carry off to their burrows in the ground. The venation does not reach the apical border of the wing, but cells *r* and *1m* are complete and separate in forewing. The females have a very powerful sting. Except for one species of *Pseudagenia*, all the New Zealand species belong to the handsome genus *Salius*. Several species are reddish-brown in colour, with orange wings; the finest of these is *S. wakefieldi* Kby. (pl. 2, fig. 20), measuring up to 18 mm. in length, and having the propodeum covered with bright golden down. *S. marginatus* Sm. is similar, but somewhat smaller, and has the wings broadly margined with fuscous. *S. monachus* Sm. is a fine species of a shiny black colour. *S. diligens* Sm. has a black body and orange wings bordered with fuscous. *S. carbonarius* Sm. and *S. nitidiventris* Sm. are much smaller, black species measuring from 6 to 9 mm. long. In Australia this genus is represented by a number of much larger, orange and black wasps, of which *S. bicolor* Fabr. and *S. tuberculatus* Sm. are perhaps the best known; the latter occurs in Western Australia. *Calopompilius* includes some handsome wasps with jet-black bodies and rich orange wings; the best known is *C. defensor* Sm., measuring up to 18 mm. long. *Batozonus tricolor*

5m. (pl. 20, fig. 10) is another fine species nearly an inch long, with rich orange vings edged with fuscous; the abdomen is black and orange-brown. *Ferreola ollaris* Fabr. is slightly smaller, with the wings and body entirely shiny black xcept for the bright orange prothorax. *Pseudagenia* contains a number of less rightly coloured species, of which *Ps. fasciata* Fabr. (fig. T44) is one of the argest, blackish with grey pubescence on abdomen, and forewings with two dark ransverse bands. Other genera represented in Australia are *Psammochares, Hemipipsis, Cryptocheilus, Cyphonyx, Anoplius, Macromeris* and *Aporus.*

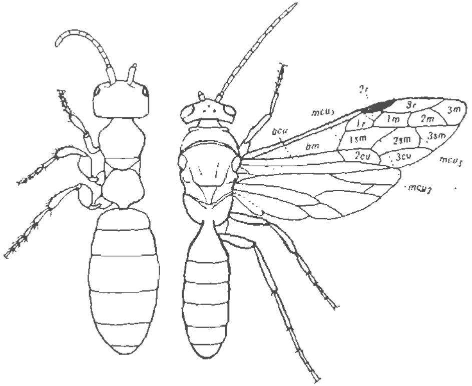


FIG. T46. *Thynnoides mesopleuralis* R. Turn., winged male and wingless female. Australia. Fam. Thynnidae. Length of male 13 mm., of female 14 mm. Lettering as in Table on p. 258, New Notation. [*A. L. Tonnoir del.*

Family 38. **Thynnidae** (Flower-wasps) [Aus. 438, N.Z. 0]. This handsome family has its headquarters in Australia, where its members may be met with almost anywhere on a hot, sunny day, but especially along the sandy coastline during the spring, visiting the blossoms of tea-tree, Angophora, Eucalyptus and other native trees and shrubs. The males fly rapidly in the sunshine; the females, which are entirely wingless, watch for them and catch hold of them with their large mandibles, and are carried off for a swift nuptial flight; while pairing, the female hangs head downwards attached to the abdomen of the male, and is usually carried about by him for a considerable length of time. The pregnant females drop off on to the ground, and proceed to burrow in search of the Scarab beetle grubs on which they lay their eggs. This is effected in the same manner as in the Scoliidae, by stinging their prey into insensibility, and then laying the egg on the body of the grub, which is devoured at leisure by the wasp-grub. The cocoons are elongate pear-shaped, much like Scoliid cocoons, but smoother and somewhat resembling brown paper in texture.

The males of this family can be recognized by their slender, graceful shape, and by their venation extending right to the terminal margin of the wing. The forewing has cells *1r* and *2r* partially united, only a small spur indicating their original separation by the cross-vein rm_1; cell *2m* is also complete; cell *3r* is elongate lanceolate in shape; cross-veins mcu_2 and mcu_3 are always present. The hypopygium is abnormally developed to clasp the female and carry her during flight. *The female has small eyes, short, curled antennae, and usually no ocelli; her thorax is elongated and divided into three separate parts, strongly constricted off from one another.*

The numerous Australian species include a large number of very handsome forms, measuring up to an inch in length. One of the most widely spread

species, though never very common, is the peculiar *Diamma bicolor* Wwd., of which the male is exceedingly rare. The female (pl. 20, fig. 6) is nearly an inch long, rich metallic purple with reddish legs and antennae, and is often met with wandering in the bush or on paths; it is known as the "Blue Ant", and stings severely. This species is remarkable in having the female much larger than the male, so that, unlike those of the rest of the family, she can never be carried about by him. It is the only known representative of the subfamily Diamminae. The Rhagigasterinae are another small subfamily with a single genus in South America, and three allied genera, *Rhagigaster, Eirone* and *Dimorphothynnus* in Australia, totalling between them about 80 species. They have the separate segments of the abdomen slightly constricted off from one another. *Rhagigaster unicolor* Guer. is 22 mm. long, black, with blackish wings; the blackish female is only about half as big. *Dimorphothynnus fimbriatus* Sm. is somewhat similar, but has clear wings and the abdomen tipped with red; the small female has the thorax and legs reddish. Both these species occur in South Queensland. The subfamily Thynninae contains the great majority of species, both in Australia and South America; the Australian species are arranged in more than thirty genera. Of these, the most abundant are *Thynnus, Epactiothynnus, Tachynomia, Hemithynnus* and *Zaspilothynnus*; the first three extend northwards into Papua or Malaya, but the two last are exclusively Australian. *Zaspilothynnus variabilis* Kby. (pl. 20, fig. 7) is a fine species with rich brown and yellow colouring, common on flowers in Eastern Australia. The allied *Z. vernalis* Turn. from S. Queensland has less clouded wings and the abdomen orange with dark brown bands joined together mid-dorsally. *Z. carbonarius* Sm. is a large, black species, common along the Eastern coastline. *Z. excavatus* Turn. is larger still, black with the apical half of the abdomen rich reddish. *Hemithynnus* contains more than 20 species very similar to those of *Zaspilothynnus; H. rufiventris* Guer. is one of the finest, an inch long, with rich red abdomen banded with dark brown. *H. inconstans* Sm. is smaller and slenderer, of variable black and orange coloration; the female is almost as large as the male, and has a red head and thorax. *Thynnus pulchralis* Sm. is a very beautiful species, 16 mm. long, with head, thorax and basal half of abdomen rich orange-brown, rest of abdomen and bases of wings black. Three fine genera confined to Western Australia are *Megalothynnus, Pogonothynnus* and *Catocheilus*. Of the more aberrant forms, we may mention the genus *Ariphron* with eleven species not at all of normal Thynnid shape; *A. petiolatus* Sm., 10 mm. long, is black, with short, petiolate abdomen. The reduction of the female in size culminates in several genera such as *Lestricothynnus, Neozeleboria* and *Thynnoturneria*; of this last, we may mention *T. cerceroides* Sm., in which the male is 8 mm., black with yellow markings, while the tiny female is entirely reddish, and barely 3 mm. long. Other genera well represented in the Australian fauna are *Agriomyia, Asthenothynnus* and *Aeolothynnus*.

This family may be considered as of distinct economic importance, as it is one of the principal checks upon grass-grubs in Australia. One blackish species, *Thynnoides mesopleuralis* Turn. (fig. T46), is found commonly in strawberry gardens in New South Wales, and the frequent occurrence of its cocoons in the soil is evidence of its value against strawberry grubs. An attempt is being made to acclimatize this species in New Zealand.

Family 39. **Scoliidae** (Hairy Flower-wasps) [Aus. 49, N.Z. 0]. These wasps, like the preceding family, are flower-haunting and burrowing species, but both sexes are winged, and the females are generally somewhat larger than the males. As with the Thynnidae, the females lay their eggs on Scarab beetle-grubs, which are devoured by the larvae. The cocoon is generally rougher in texture and less pear-shaped than in the Thynnidae. The species are all very hairy, and can be at once distinguished from the Thynnidae by the fact that the venation does not reach to the terminal margin of the wings, and cells *1r* and *2r* together form a single cell (fig. T45, *r*). A number of the Australian species are fine, large insects. *Campsomeris (Trielis) ferruginea* Fabr. (pl. 20, fig. 8) is a huge species from North Queensland, 32 mm. long, of a general rich orange-brown colour. *C. (Trielis) anthracina* Burm. is a large black species, nearly an inch long, with black wings showing rich, steel-blue reflections; the male is somewhat smaller, with duller wings, and has a pair of rounded orange spots on the abdomen. *C. (Dielis) tasmaniensis* Sauss. is about an inch long, blackish with shaded brownish wings, and abdomen broadly banded in orange-brown; the male is somewhat smaller and slenderer. This species is widely distributed from Western Australia to Tasmania and New South Wales. *Scolia (Discolia) verticalis* Fabr. is a common species about 15 mm. long, black with very dark, steely blue wings and

a bright orange head; this and the larger *S.* (*Discolia*) *soror* Sm., which is entirely black, are often found in gardens in Sydney and Brisbane. *S.* (*Triscolia*) *frontalis* Sauss. (pl. 20, fig. 9) is similar but somewhat larger, and has two orange spots on the abdomen. All the above belong to the subfamily Scoliinae. The Anthoboscinae are a peculiar group of smaller wasps, 6 to 12 mm. long, black in colour, represented by a number of species of *Anthobosca* found in Queensland; one of the finest is *A. flavicornis* Sauss., 12 mm., with darkly shaded wings and yellow antennae; *A. lagardei* R. Turn. (fig. T45) is a smaller species, shining black, with wings only slightly tinted

Family 40. **Mutillidae** (Solitary Ants) [Aus. 197, N.Z. 0]. This family agrees with the Thynnidae in having the females wingless with short, curled antennae, and with the Scoliidae in the venation not reaching to the terminal margin of the wings and in the hairiness of the body. It differs from both in having the venation more reduced than in any other family of the Vespoidea; the forewings have cells *r* and *1m* closed, *2m* open, and there are no closed cells at all in the hindwings.* The males are sometimes larger, sometimes smaller than the females, and often very differently coloured. The species are not flower-haunting, the winged males hunting about on the ground or on tree-trunks; the females are burrowers, and are commonly known as "solitary ants". All the species are secondarily parasitic upon other wasps, ants or bees. Owing to the great differences in coloration between male and female, it may well be that a number of the Australian specific names are synonyms. With few exceptions, they belong to the great genus *Ephutomorpha*, which is found only in Australia and Papua. Most of the species occur in the warmer parts of Australia, and are only to be found during the hottest part of the day. *E. ferruginata* Wwd. (pl. 21, figs. 10, 11) is one of the best known species; the female is about 11 mm. long, dark reddish brown, with pale hairs on the legs and a very distinct patch of whitish hairs on the abdomen; the male is considerably larger, dull black, with pale greyish hairs on the head. *E. rugicollis* Wwd. is larger; the female is black, clothed with whitish hairs, and with a row of whitish hairy patches down the abdomen; she measures up to 18 mm. in length, whereas the male is much smaller, somewhat similarly marked, with the wings shaded with brown. Amongst a number of smaller species, often found running up tree-trunks, we may mention *E. cordata* Sm., *E. edmondi* André and *E. burkei* André.

Section DIPLOPTERA†.

Family 41. **Eumenidae** (Solitary Wasps) [Aus. 160, N.Z. 0]. This family can be recognized at once by the longitudinally folded wings, coupled with the solitary habits of the species, which work in pairs. They are called "Mason Wasps" in Australia, but this name is used for the Sphecoidea in New Zealand, where Eumenidae are entirely absent. In America they are called "Mud-daubers". They are of very diverse shapes, some having a very long petiole, others scarcely any at all. They build clay nests of various shapes and store them with Lepidopterous caterpillars. The subfamily Odynerinae is well represented in Australia by several fine genera. *Odynerus* contains a large number of species of small, rather stout wasps, mostly about half-an-inch long, of a banded orange and black coloration. *O. nigrocinctus* Sauss. is a handsome species, bright orange with a broad, black band on thorax and abdomen; the wings are orange shading to dull brown apically. The allied *O. mirabilis* Sauss. (pl. 21, fig. 12) has more black on thorax and abdomen but paler wings, orange-tinted along costa of forewing only. *O. bicolor* Sauss. is a darker species, mostly black, with distal two-thirds of abdomen dull orange, and wings blackish. *Rhynchium* contains several species very similar to *Odynerus* in shape and coloration, but of considerably larger size. *Rh. abispoides* M.W. (pl. 21, fig. 13) is very like a large *O. bicolor*, nearly an inch long and stoutly built. The species of *Abispa* (*Monerebia*) are the giants of the group; *A. ephippium* Fabr. measuring up to 30 mm. or more, very robust, and with bright orange coloration banded with black, much as in *O. bicolor*. The Alastorinae are represented by numerous species of *Paralastor*, mostly very similar in appearance to *Odynerus*, but with somewhat different venation. *P. eriurgus* Sauss. is a Queensland species closely resembling *O. bicolor*, but with the wings smoky instead of orange. All the above genera have the petiole so short that the gaster appears almost sessile. In the Eumeninae the petiole is very distinct, often long;

*Venational characters not always true for non-Australian species.

†For an alternative classification of this group, see Bequaert, Bull. Amer. Mus. Nat. Hist., 1918-9 xxxix.

the principal genera are *Montezumia, Macrocalymma, Elimus, Discoelius* and *Eumenes*. The first two have short but very distinct petioles, very slender in *Montezumia*, but swollen distally into a large node armed with teeth in *Macrocalymma*. The others have the petiole considerably longer than the rest of the abdomen, and often more or less enlarged distally. The finest species belong to *Eumenes*; *E. arcuatus* Fabr. is about an inch long, black marked with lemon yellow, and has a very slender petiole; *E. latreilli* Sauss. (pl. 20, fig. 11) is even larger, deep orange, banded with black on thorax and across abdomen, the wings tinted with orange, and the petiole somewhat swollen. Both these species come from Queensland.

Family 42. **Masaridae** [Aus. 22, N.Z. 0]. This small family is represented in Australia by more than twenty species of the genera *Euparagia* and *Metaparagia*, which differ from other Diploptera in having the wings not folded longitudinally when at rest. *E. deceptor* Sm. (pl. 21, fig. 14) is a handsome wasp about half-an-inch long, black, marked with deep orange spots and bands, and with a dark band along costa of forewings. Other well-known species are *E. bidens* Sauss., *E. decipiens* Shuck. and *M. maculata* M-W. They are sometimes called "Shining Wasps", but the name is unsuited to the Australian species, which are not particularly shiny.

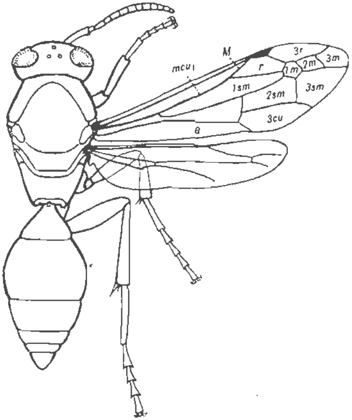


FIG. T47. *Polistes humilis* Fabr., female, Australia and New Zealand (Introd.). Fam. Vespidae. Length 14 mm. Lettering as in Table on p. 258, New Notation; except $r = 1r + 2r$. [*E. S. Gourlay del.*

Family 43. **Vespidae** (Social Wasps) [Aus. 22, N.Z. 0]. This family, to which the well-known English Wasp and Hornet belong, is distinguished by the longitudinally folded wings, the highly developed social habit, and the presence of males, females (queens) and workers in each nest. The nests are built of a papery substance, and are often of very beautiful design. The workers forage for various insects, chiefly caterpillars, which they kill and masticate, feeding the larvae in the cells from day to day with the food thus prepared; hence the economic value of these insects is considerable. Nevertheless they are objectionable owing to their fondness for fruit and also owing to their aggressive habits; if a person disturbs one of their nests unawares, the whole colony will sometimes fly at him together and sting him severely on the face or hands. The Australian species belong to the two genera *Polistes* and *Ropalidia* (*Icaria*). One of the largest species is *P. tepidus* Fabr. (pl. 21, fig. 15), from Queensland, nearly an inch

long, dull black, with orange antennae, pronotum and apical three-fourths of abdomen, and wings tinted with orange. *P. variabilis* Fabr. is a much commoner species, black and dull reddish brown in colour and about 16 mm. long; its beautiful papery nests are often met with in Eastern Australia; they are circular in outline, and are built downwards from a slender stalk, the cells being arranged as in a honeycomb. They vary greatly in size, and may be found as much as six inches or more in diameter. Another common species is *P. humilis* Fabr. (= *P. tasmaniensis* Sauss.) (fig. T47) which extends southwards into Tasmania. This wasp has been accidentally introduced into North Auckland Province, New Zealand, and is spreading with considerable rapidity southwards. The genus *Ropalidia* contains a number of smaller species with the petiole longer and slenderer than in *Polistes*; they are commonest in Queensland. *R. gregaria* Sauss., about 8 mm. long and *R. socialistica* Sauss. (pl. 21, fig. 16) are the best-known species. They live in smaller colonies, and build their nests in linear form along a slender stalk. *R. cabeti* Sauss., a small, yellowish species, makes huge nests, more than two feet long, on tea-tree. Both *Polistes* and *Ropalidia* feed their larvae on masticated caterpillars.

Superfamily X. SPHECOIDEA*.

This group includes all the true stinging wasps in which the pronotum is not produced backwards on either side to meet the tegula. Forewings always with cells *1r* and *2r* fused into a single cell *r* (figs. T48, 49). They are all solitary species, with very diverse habits. Some make burrows in the ground, others build nests of clay. Some store their nests with spiders, others with flies, caterpillars, or even grasshoppers and cicadas. Species of the families Arpactidae and Nyssonidae, which attack flies, are called in Australia "Policeman Flies". In New Zealand those species which construct clay nests in cracks and crannies are called "Mason Wasps"†, but this name is elsewhere more generally used for the Eumenidae. A number of species are attracted to houses, where they will make nests in keyholes, behind book-shelves, or in any suitable narrow or concealed place; others build nests on verandahs or in outhouses. The classification of the group is a most difficult problem, as it appears almost impossible to define some of the so-called "families" satisfactorily. The characters used for subdivision are almost all of lower value than those in use for dividing the Vespoidea, and perhaps there is a good deal to be said for the view that the whole group really consists of a single family (Crabronidae or Sphecidae) of about the same value as the Eumenidae. However, as many authors now divide the group into families, we shall offer a key based on the Australian and New Zealand material only. The group is very abundant in Australia, there being about 360 known species, representing no less than thirteen "families". In New Zealand only about 14 species are known, belonging to the Larridae, Trypoxylidae, Arpactidae and Crabronidae. The families are distinguished as follows:—

1. Pronotum well developed, as long as wide, or longer. Fam. 44. AMPULICIDAE
   Pronotum short, more or less collar-like, distinctly wider than long. 2
2. Head very large, usually wider than thorax, and with the eyes placed at the antero-lateral angles, with very large postocular area behind them. 3
   Head normal, seldom wider than thorax, and with eyes occupying most of the lateral portions. 4
3. Forewing with cells *r*, *1m* and *2m* closed (three closed cubital cells); integument rugose. Fam. 51. PHILANTHIDAE
   Forewing with cell *r* only closed (a single closed cubital cell); integument smooth. Fam. 56. CRABRONIDAE
4. Inner margin of eyes deeply notched or excised near middle. Fam. 54. TRYPOXYLIDAE
   Eyes not as above. 5
5. Petiole very slender, often long. Fam. 55. SPHECIDAE
   Petiole either short, or not appreciably developed. 6
6. Cell *3r* with a minute cell *ap* attached distally. (radial cell appendiculate). Fam. 50. LARRIDAE
   Cell *3r* without such a cell attached (radial cell not appendiculate). 7

*See footnote on p. 300.
†Or, quite incorrectly, "Mason Bees."

7. Gaster broadest near base, more or less pear-shaped, without visible petiole. Fam. 52 BEMBICIDAE
Gaster broadest near middle or beyond.
8. A short but distinct, slender petiole present and visible. Fam. 53. PEMPHREDONIDAE
No slender visible petiole present. 9
9. Labrum well developed, distinctly visible as a segment of a circle below clypeus. 10
Labrum very short, barely or not at all visible below clypeus. 11
10. Small to medium species (up to 12 mm. long), forewing with M_{3+4} (cubital vein) not reaching the termen. Fam. 46. STIZIDAE
Very large species (up to 30 mm. long), forewing with M_{3+4} (cubital vein) reaching the termen. Fam. 45. EXEIRIDAE
11. Middle tibia with one apical spur, or none. Fam. 49. NITELIDAE
Middle tibia with two apical spurs. 12
12. Cell *2m* (third cubital cell) of forewing quadrangular. Fam. 47. ARPACTIDAE
Cell *2m* (third cubital cell) of forewing triangular or petiolate. Fam. 48. NYSSONIDAE

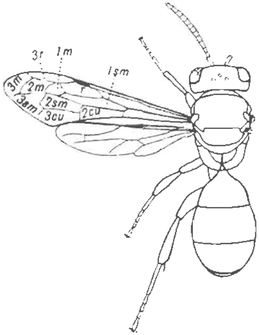


FIG. T48. *Arpactus chrysozonus* R. Turn., female, New Zealand, fam. Arpactidae. Length 10.5 mm. Lettering as in Table on p. 258, New Notation, except $r = 1r + 2r$. [*E. S. Gourlay del.*

Family 44. **Ampulicidae** [Aus. 10, N.Z. 0]. A small family, represented in Australia only by a few species of the genus *Aphelotoma*; these are small, slender wasps about 5 mm. long, the best known being *A. tasmanica* Wwd. from Tasmania and *A. rufiventris* R. Turn. from Queensland.

Family 45. **Exeiridae** (Cicada-hunters) [Aus. 1, N.Z. 0]. This family is represented in Australia by the single species *Exeirus lateritius* Shuck. (pl. 21, fig. 23 and fig. T2), the Great Australian Cicada-hunter; it is 33 mm. long, blackish, with antennae, most of the legs and apical two-thirds of abdomen orange, sometimes with narrow black bands; the wings are orange-tinted. It is quite common some years in Eastern Australia, where it makes large mounds of freshly turned-up clay soil, pierced with a number of burrows which lead far down into the ground and end in a number of galleries or "catacombs"; each burrow is independent of the others, but usually all lead inwards towards the centre. These wasps forage far and wide, attacking large Cicadas in the trees, and stinging them so that they fall senseless to the ground. Then the wasp turns the Cicada on to its back, and proceeds to ride its victim straight to its burrow, sitting astride it and pushing it along with its powerful hind-legs. They have been seen to travel

thus a full hundred yards, going straight over every object which lies in a direct line with the burrow, and sometimes hauling their victims over large tree-trunks. On arrival at the entrance to the burrow, the numbed Cicada is tipped or dragged down it, and laid up on one of the shelves of the catacomb below. A large number of Cicadas are thus stored, and one egg is laid on each of them. The wasp grub devours the Cicada and forms a large earthen cocoon alongside its remains. If the weather is dry, they frequently remain two or three years in the larval state inside the cocoon before pupating.

Family 46. **Stizidae** [Aus. 7, N.Z. 0]. These are small wasps closely allied to the previous family in structure. All the Australian species belong to the genus *Stizus*. *S. turneri* Frogg. is dull fuscous, about 8 mm. long, with a silvery-white clypeus and labrum.

Family 47. **Arpactidae (Gorytidae)** [Aus. 28, N.Z. 2]. Medium-sized wasps which attack flies, killing them and carrying them off to their burrows in the ground. All the species belong to the genus *Arpactus* (*Gorytes*). *A. chrysozonus* R. Turn. is a handsome, orange and black species, 10 mm. long, from Queensland. *A. carbonarius* Sm. is a black species found in New Zealand. These wasps and the members of the following family are known as "Policeman Flies" in Australia.

Family 48. **Nyssonidae** [Aus. 44, N.Z. 0]. Included in this group are two subfamilies, Nyssoninae and Paranyssoninae; the former have cell *2m* (third cubital cell) of the forewing triangular, the latter have it petiolate above; cells *r* and *1m* are often fused together. In Australia the Nyssoninae are represented by the genus *Nysson*; *N. brisbanensis* R. Turn. is a well-known species, 8 mm. long, dark brown marked with dull orange. Several genera of Paranyssominae occur, the chief being *Sericophorus*, *Zoyphium* and *Sphodrotes*. *Sericophorus relucens* Sm., 8 mm. long, with metallic bronze bands on the abdomen, is one of the best known of the "policeman flies" of Eastern Australia.

Family 49. **Nitelidae** [Aus. 4, N.Z. 0]. A small family represented in Australia only by species of *Nitela*, mostly from the tropics.

Family 50. **Larridae** [Aus. 53, N.Z. 4]. This family contains medium-sized, mostly thick-set wasps of a dark colour, easily distinguished by a tiny extra cell *ap* extending distally from the end of the long radial cell *3r*. They are represented in Australia by several genera, of which the best known are *Tachytes*, *Larra*, *Tachysphex* and *Notogonidea*. *Tachytes* is also represented by four species in New Zealand, all black insects. *T. nigerrimus* Sm. (pl. 21, fig. 24) is 10 mm. long, entirely shiny black; *T. sericops* Sm. is smaller, 8 mm. long, slenderer in build, and has the dull black abdomen banded with silvery-grey pubescence. Of the Australian species, *T. approximatus* R. Turn. is a handsome species, half-an-inch long, blackish with bands of pale golden pubescence on abdomen, and wings tinged with yellow. *Tachysphex australis* Sauss. is known to attack and break open the cells of *Sceliphron laetum* Sm. (fam. Sphecidae, see p. 300), using the stored provender of spiders as food for its own larvae, and resealing the cells after the egg is laid. Other species of this genus are known to attack grasshoppers and other Orthopterous insects, and drag them off to their burrows in the ground. The species of *Larra* found in Australia are more slenderly built than *Tachytes*; *L. melanocnemis* R. Turn. is 14 mm. long, shiny black, with dorsally interrupted bands of bright silvery pubescence on the abdomen.

Family 51. **Philanthidae** [Aus. 25, N.Z. 0]. A family of peculiar wasps with very large heads, rugose integument and with cells *r*, *1m* and *2m* (three cubital cells) closed in forewing. The Australian species belong to the genus *Cerceris*, medium-sized wasps of dull black or brown coloration banded with yellow or orange, and having the abdominal segments somewhat constricted off from one another. These wasps are often found visiting flowers, and are also greatly attracted by the sweet secretions of Coccidae. They are said to store their burrows with various kinds of beetles. *C. froggatti* R. Turn. (pl. 21, fig. 25) is a fine species from Queensland, 18 mm. long, black, with the tibiae, tarsi and apical half of abdomen orange red.

Family 52. **Bembecidae** [Aus. 27, N.Z. 0]. These handsome wasps are easily recognized by the shape of the gaster, which is very broad basally, tapering to a sharp point apically, so as to be more or less pear-shaped. They make shallow burrows in sandy soil, and capture flies on the wing, holding them close beneath their bodies as they carry them to their burrows, and covering each burrow up after an egg has been laid in it. All the Australian species belong to the genus *Bembex*, one of the finest being *B. furcata* Er. (pl. 21, fig.

26) measuring up to 20 mm. in length, shiny black, with dorsally interrupted bluish-grey bands on abdomen. Other well-known species are *B. palmata* Sm., *B. raptor* Sm., *B. variabilis* Sm., *B. tridentifera* Sm. and *B. vespiformis* Sm.

Family 53. **Pemphredonidae** [Aus. 21, N.Z. 0]. This family contains small to medium-sized wasps recognizable by having a distinct though short petiole. It is represented in Australia by the genus *Harpactophilus*. *H. steindachneri* Kohl. is a small wasp 6 mm. long with blackish head and thorax and bright red abdomen and legs.

Family 54. **Trypoxylidae*** [Aus. 57, N.Z. 4]. Small to medium-sized wasps with the inner margin of the eyes strongly excised or notched near the middle; forewing with only cell *1r*, or cells *1r* and *1m*, closed (one or two closed cubital cells). The Australian species belong to the genera *Pison*, *Pisonoides* and *Trypoxylon**; there are also four species of *Pison* in New Zealand. The members of this genus are well-known as intruders in houses, blocking up key-holes with their clay nests, or building behind pictures, book-shelves, etc., or in old clothes or rolled up blinds. These nests are stored with spiders. *Pison spinolae* Shuck. (pl. 21, fig. 27) is the commonest of the New Zealand species; it is black, the abdomen shiny with slender bands of grey pubescence between the segments; the male measures 10 mm., the female 14 mm. long. This species is also very common in Australia. The Australian *P. tuberculatus* Sm. is slightly smaller and slenderer, with abdomen banded in black and dull olive; *P. ruficornis* Sm. is only 8 mm. long, with red abdomen and reddish antennae. The genus *Trypoxylon* has short wings with cell *r* but not cell *1m* closed in forewing; the after-body is long and very slender, giving the insect a superficial resemblance to an ichneumon. *T. connexum* R. Turn. (fig. T49) is a black species not uncommon in Eastern Australia.

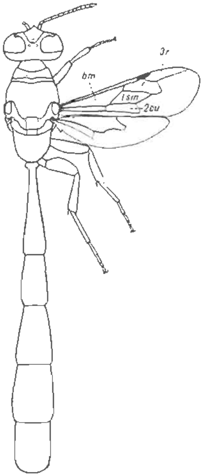


FIG. T49. *Trypoxylon connexum* R. Turn., female, fam. Trypoxylidae. Length 13 mm. Lettering as in Table on p. 258, except $r = 1r + 2r$.
[*E. S. Gourlay del.*

Family 55. **Sphecidae**† [Aus. 48, N.Z. 0]. Medium to very large wasps of handsome form, distinguished by the very slender, stalk-like petiole followed by the greatly swollen gaster; the propodeum is always long and with its dorsal surface horizontal (a character also noticeable in some Larridae). Forewing with cells *r*, *1m* and *2m* closed. Most of the Australian species are included in the genera *Chlorion*, *Sphex* (=*Ammophila*) and *Sceliphron* (=*Pelopaeus*). The numerous species of *Chlorion* vary greatly in size, the females being often three or four times as large as the males. *Ch. saevum* Sm. (pl. 21, fig. 28) from Western Australia has the females ranging from 18 mm. long to huge insects nearly 30 mm. long, while the males measure about 12 mm. This insect has a dull fuscous thorax, shiny black abdomen and legs, and the wings are dull orange with a broad margin slightly tinged with fuscous. *Ch. fumipenne* Sm. is a fine black species from Queensland, with wings almost entirely black. *Ch. vestitum* Sm., *Ch. opulentum* Sm., and *Ch. cognatum* Sm. are all well known species in Eastern Australia. These wasps make burrows in the

*Greek *trupao* to bore, *xulon* wood, stem *xyl-*, hence Trypoxylidae, not Trypoxylonidae.

†From genus *Sphex*, Greek *sphex* a wasp, stem *sphec-*, hence family Sphecidae, not Sphegidae, superfamily Sphecoidea, not Sphegoidea.

ground, which they store with grasshoppers and other insects. The genus *Sceliphron* contains some very handsome species with long, slender petioles; they are true "mud-daubers", building their nests with moist clay in hollow tree-trunks, sheltered parts of rocks, or even on walls or verandahs of houses. *S. laetum* Sm. (pl. 20, fig. 12) is a common, yellow and black species measuring from 20 mm. up to nearly 30 mm. in length; it stores its cells with spiders. The genus *Sphex* contains handsome species very like those of the preceding genus, but with the wings shorter and the abdomen longer and slenderer by comparison; they make burrows and store them with caterpillars. *S. instabilis* Sm. is a fine species measuring up to 30 mm. long, with black head and thorax, deep orange legs and petiole, and the swollen end of the abdomen black. *S. suspiciosus* Sm. is a smaller, commoner species, black, with the gaster reddish.

Family 56. **Crabronidae** [Aus. 34, N.Z. 4]. A peculiar family with large, squarish or sub-rectangular heads similar to those of the Philanthidae, but with the integument smooth and the forewing with cell *r* closed, cell *m* (=*1m* +*2m*+*3m*) open. The New Zealand species belong to *Rhopalum*, a genus with a slender petiole swollen distally into a node constricted off from the gaster; they are all black insects, *Rh. carbonarium* Sm. (pl. 21, fig. 29) entirely so, while *Rh. albipes* Sm. has cream-coloured tarsi, and *Rh. perforator* Sm. has the distal half of the fore femora bright orange. Of the Australian species of this genus we may mention *Rh. tricolor* Sm. from Queensland, half-an-inch long, with black head and thorax, lemon-coloured antennae and forelegs, rest of legs and gaster reddish, the latter heavily banded with black apically. *Dasyproctus* contains some smaller species with shorter petiole. The species of *Crabro* are stouter in build, with short petiole and broad gaster; the head is enormous and almost square. *C. cinctus* R. Turn. is a well-known species, half-an-inch long, with gaster banded with black and deep orange-red. These insects burrow into the stems of trees and shrubs, or into dead wood, and store their nests with flies.

Superfamily XI. APOIDEA (ANTHOPHILA).
(Bees).

The Bees form a very distinct group characterized by the branched, plumose or feathered hairs present on the body or legs. They differ from the Vespoidea and agree with the Sphecoidea in having the pronotum short, collar-like and not extending back laterally to the tegulae. The mouth-parts of the more primitive families, known as the "short-tongued" bees, differ little from those of wasps, but in the higher families a long "tongue" is developed as an extension of the fused glossae (fig. T3, F); this tongue is armed at the tip with a kind of spoon and some swollen hairs for the purpose of gathering nectar from flowers. As the hairs of the tongue get covered with pollen-grains from flowers previously visited, the ovary is fertilized by pollen from another blossom at the same time that the nectar is extracted. All except the parasitic groups of bees are of immense value to man economically owing to this habit. Most of the bees are also pollen-gatherers, and have the tibia and first segment of the tarsus of the hind leg modified for this purpose, either by being covered with dense pollen-collecting hairs, or by having a smooth, polished "pollen-plate" on the outer surface of the tibia, surrounded by hair to keep the pollen in place. Some forms have small, dense brushes of hairs (scopulae) on the underside of the abdomen. The group is exceedingly abundant in Australia, no less than 925 species being known; in New Zealand, native bees are confined to the three most archaic families, Colletidae, Hylaeidae and Andrenidae, all short-tongued forms, and less than 20 species are known, though individuals are often very numerous on native flowering shrubs.

The nests of bees are made in all sorts of situations and in many different ways. Each nest is formed of a number of cells which are generally stored with a mixture of pollen and the manufactured product known as honey, formed by the swallowing and regurgitation of nectar; this mixture is called "bee-bread". The Honey-bees, however, store their cells with pure honey. One egg is laid in each cell, and sufficient food is provided for the larva to reach its full size. Most of the larvae live in closed cells, but those of the social bees live in open cells and are fed by the workers. Some larvae spin cocoons, others pupate in the empty cell. The parasitic bees lay their eggs in the cells of other species; and their larvae, hatching and growing more quickly, take the food-supply from its rightful owners, which either die of starvation or are themselves devoured by the parasites.

The classification of Bees is not an easy task. In the long-tongued bees, there is a hinge between the cardo and stipes of the maxillae, which allows of the tongue and associated parts of the labium being withdrawn and partially folded backwards. As the form of the tongue is one of the best characters for classification this fact must be borne in mind when examining the organ, and, if necessary, a dissection or more careful examination of the parts must be made. Most of the specimens met with being females, it is not a difficult matter to become familiar with the parasitic groups, which are distinguished by the lack of pollen-collecting apparatus. The venation of the forewing furnishes some good characters, the chief of which are the shape of the radial cell *3r*, the form of the pterostigma, and the number of closed median (cubital) cells. The cross-vein rm_1 is always absent, so that cells *1r* and *2r* are combined, the single cell so formed being denoted by *r*. The ten families found in Australia may be classified as follows:—

1. Tongue short, broad and obtuse at apex. 2
   Tongue either long, or, if short, then sharply pointed. 3
2. Smooth bees, mostly small, with only cells *r* and *1m* closed, *2m* open (two closed cubital cells) in forewing. Fam. 58. HYLAEIDAE
   Hairy bees of moderate size, with cells *r*, *1m* and *2m* closed (three closed cubital cells) in forewing. Fam. 57. COLLETIDAE
3. Tongue short or of moderate length, sharply pointed; burrowing bees. Fam. 59. ANDRENIDAE
   Tongue very slender, long to very long; mostly non-burrowing forms. 4
4. Hind tibiae without apical spurs; social bees with males, females and workers. Fam. 66. APIDAE
   Hind tibiae with apical spurs; non-social bees, without workers. 5
5. Parasitic bees, the females without pollen-collecting apparatus. 6
   Not parasitic; females always with pollen-collecting apparatus. 8
6. Forewing with cells *r*, *1m* and *2m* closed (three closed cubital cells). 7
   Forewing with only cells *r* and *1m* closed, *2m* open (two closed cubital cells). Subfam. COELIOXINAE of Fam. 63. MEGACHILIDAE
7. Radial cell *3r* of forewing sharply pointed apically; coloration wasp-like. Fam. 60. NOMADIDAE
   Radial cell *3r* of forewing bluntly rounded apically; coloration of bright patches due to hairs. Fam. 61. MELECTIDAE
8. Forewing with very long, narrow radial cell, *3r*; large, robust forms; (carpenter bees). Fam. 64. XYLOCOPIDAE
   Forewing with radial cell *3r* not very long and narrow. 9
9. Forewing with cells *r*, *1m* and *2m* closed (three closed cubital cells). Fam. 62. ANTHOPHORIDAE
   Forewing with only cells *r* and *1m* closed, *2m* open (two closed cubital cells). 10
10. Forewing with strong, swollen pterostigma; anterior margin of radial cell *3r* curving away from costa distally. Fam. 65. CERATINIDAE
    Forewing with pterostigma not strong or swollen; anterior margin of radial cell *3r* formed entirely by costa; leaf-cutting bees. Fam. 63. MEGACHILIDAE

Family 57. **Colletidae** [Aus. 137, N.Z. 8]. Moderate-sized, hairy bees with very short, broad and obtuse tongue; forewing with cells *r*, *1m* and *2m* closed. These bees burrow in the ground, especially in clayey soil; the middle and hind femora have well-developed pollen-carrying hairs. *Paracolletes* contains the great majority of the species. *P. obscurus* Sm. is a common species found from Western Australia to Tasmania and New Zealand. *Anthoglossa* is represented by six Australian species. The genus *Gastropsis* has three Australian species, of which *G. pubescens* Sm. (pl. 21, fig. 30) is the best known, widely distributed, covered with dense, pale hairs; the antennae have seg. 3 forming a slender stalk to the thickened distal portion. Several other genera are represented in Australia by one or two species only.

Family 58. **Hylaeidae (Prosopidae)** [Aus. 318, N.Z. 8]. Smooth, flower-haunting bees, mostly smaller than Colletidae; the tongue similar (fig. T3, E), but the forewings with only cells *r* and *1m* closed, *2m* combined with *3m*; they have no pollen-collecting apparatus, but brush the pollen into their mouths with their forelegs. This primitive family is exceedingly abundant in individuals both in

Australia and New Zealand. Of the Australian species, about 100 belong to *Hylaeus* (*Prosopis*) and nearly 90 to *Euryglossa*. The former are small black bees, marked with yellow or red on the face or thorax. *H. cognatus* Sm. (pl. 20, fig. 13) is a handsome Western Australian species. *Euryglossa chalcosoma* Ckll., barely 3 mm. long, is the smallest of all Australian bees; other members of the genus however measure up to 10 mm., such as the handsome, wasp-like *E. crabronica* Ckll. from Queensland. *Meroglossa*, *Pachyprosopis* and *Palaeorrhiza* are all well represented in Australia. *Palaeorrhiza reginarum* Ckll. is a fine species, 12 mm. long, found in Queensland, of a bright, metallic, steely blue colour. *Hylaeoides concinna* Fabr. is a slightly larger species, black with dark red bands on abdomen, wide-spread throughout Eastern Australia. The New Zealand species all belong to *Hylaeus* (*Prosopis*); *H. capitosus* Sm. (fig. T50), almost entirely black, is one of the commonest species.

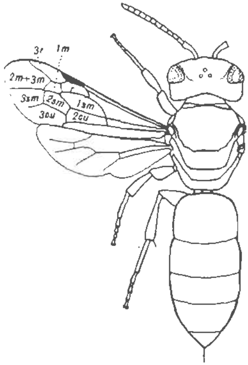


Fig. T50. Hylaeus (Prosopis) capitosus Sm., female, New Zealand, fam. Hylaeidae. Length 10 mm. Lettering as in Table on p. 258, New Notation, except $r = 1r + 2r$. [*E. S. Gourlay del.*

Family 59. **Andrenidae** [Aus. 265, N.Z. 4]. Burrowing bees of medium size, with the tongue short and strongly pointed; forewing with cells *r*, *1m* and *2m* closed, and, except in Nomiinae, with the radial cell *3r* sharply pointed distally. Pollen is collected on the hairs of the femur and tibia of middle and hind legs, and is often rolled into a large ball. These bees are of great economic value to man owing to the fact that they are one of the principal agents in the pollination of fruit trees. The numerous Australian species belong to eight genera. New Zealand has only four described species of *Halictus*. The Nomiinae are represented in Australia by about 40 species of *Nomia*, and one or two of *Nomoides* and *Reepenia*, they are fairly stout, blackish bees of moderate size, with the radial cell bluntly rounded apically. The Halictinae are represented by about 130 species of the widespread genus *Halictus*, more than 50 of *Parasphecodes* (especially numerous in Tasmania and the southern parts of Australia), a few belonging to *Mellitidia* and one to *Andrenopsis*. In the Sphecodinae, there is only a single species of *Sphecodes*, *S. profugus* Ckll. from Queensland, a small, blackish bee with abdomen partially dark red; this species is parasitic on *Halictus*.

Family 60. **Nomadidae** [Aus. 1, N.Z. 0]. A small family of parasitic or "cuckoo" bees, with elongate tongue, no pollen-collecting apparatus, forewing with radial cell *3r* sharply pointed apically, and coloration somewhat wasp-like. There is a single species, *Nomada australensis* Perk., found in North Queensland.

Family 61. **Melectidae** [Aus. 15, N.Z. 0]. A family of parasitic or "cuckoo" bees, differing from the preceding in the robust build, the bright mark-

ings due to patches of short hairs, and the forewing with the radial cell *3r* bluntly rounded apically. Represented by twelve species of the genus *Crocisa* in Australia, all very handsome, stout bees, black with whitish or bright blue markings; *they are parasitic on Anthophoridae. C. lamprosoma* Bd. (*pl. 20, fig. 14*) *occurs* throughout Eastern Australia.

Family 62. **Anthophoridae** [Aus. 17, N.Z. 0]. Tongue fairly long; hairy, pollen-collecting bees; forewing with cells *r*, *1m* and *2m* closed. Most of the Australian species belong to the widespread genus *Anthophora*; these are stout bees, superficially resembling small humble-bees, with very hairy thorax and hind-legs, and banded abdomen. *A. bombiformis* Sm., *A. cingulata* Fabr. and *A. pulchra* Sm. (pl. 20, fig. 15), are three well-known species from Queensland. A single species of *Tetralonia* is known from Australia.

Family 63. **Megachilidae** (Leaf-cutter Bees) [Aus. 123, N.Z. 0].

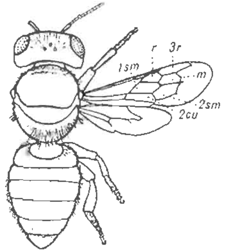


FIG. T51. *Megachile quinquilineata* R. Turn., female, Australia. Length 10 mm. Lettering as in Table on p. 258, New Notation, except $m=1m+2m$, $r=1r+2r$. [*E. S. Gourlay del.*

Tongue long and very slender; forewing with only cells *r* and *m* (=*1m*+*2m*) closed, pollen-collecting apparatus on underside of abdomen (absent in Coelioxinae). The Megachilinae include the true leaf-cutter bees, which cut circular pieces out of leaves with their mandibles, and use them in the construction of their nests, which are built in old stumps, posts, cracks in walls, or under stones. Others make resinous cells, scraping the resin or "gum" off the bark of eucalypts and carrying it away in their mandibles to their nests. They are medium-sized, dark coloured bees, not very hairy; the great genus *Megachile* contains all but seven of the species, the remainder belonging to *Dianthidium* and *Thaumatosoma*. The group is especially numerous in Western Australia and Queensland, but only three species are recorded from Tasmania, one of which is the widespread species *Megachile chrysopyga* Sm.; other well-known species are *M. quinquilineata* R. Turn. (fig. T51), *M. apicata* Sm., *M. cetera* Ckll., *M. macularis* D.T. and *M. mystacea* Fabr.; the last-named extends from Victoria through Queensland to India. The Coelioxinae, including the genera *Coelioxys*, *Androgynella* and *Lithurgus*, are parasitic bees, the first two genera on the true Leaf-cutters, the last-named on *Xylocopa*; they can be recognized by the absence of the pollen-collecting apparatus. Four species of *Coelioxys* are recorded from Australia, the best known being *C. albolineata* Ckll. from Queensland.

Family 64. **Xylocopidae** (Carpenter-bees) [Aus. 3, N.Z. 0]. Large, stout bees with long, slender tongue, stout, hairy legs, with dense brush of pollen-collecting hairs on hind tibia and tarsus; forewing with long, narrow radial cell *3r*; cells *r* and *1m* closed, *2m* variable. The three Australian species are confined to the eastern part of the continent. They make galleries in dry wood or in the stems of grass-trees. *Xylocopa* (*Mesotrichia*) *bryorum* Fabr. (pl. 20, fig. 16) is a huge species, measuring an inch in length, and very broad in proportion; the male has the wings shaded brown, the thorax covered with golden hair, the abdomen with golden down and the legs with long yellow hairs; the female has the gaster and legs black. The genus *Lestis* contains two handsome but slightly smaller species, *L. bombylans* Fabr. from Queensland and *L. aerata*

Sm. (pl. 21, fig. 32) from New South Wales and Victoria, which make nests in the stems of grass-trees (*Xanthorrhoea*); they are dark metallic green in colour, with shaded wings.

Family 65. **Ceratinidae** [Aus. 37, N.Z. 0]. Medium-sized bees, not stout, with long slender tongue, legs normal, without a thick brush of pollen-collecting hairs on hind tibia and tarsi; forewing with a strong pterostigma and normal radial cell *3r*, and with cells *r* and *m* (=*1m*+*2m*) closed. These bees make nests by burrowing in the stems of trees and shrubs, or into old posts. Twenty of the Australian species belong to the genus *Exoneura*; they are dark in colour, 6 to 10 mm. long, with smooth bodies. *E. bicolor* Sm. ranges from Tasmania to northern New South Wales. Five species of the allied genus *Allodape* (fig. T52) occur, and one of *Neoceratina*.

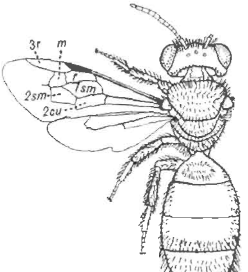


Fig. T52. *Allodape diminuta* Ckll., female, Australia. Fam. Ceratinidae. Length 7.5 mm.

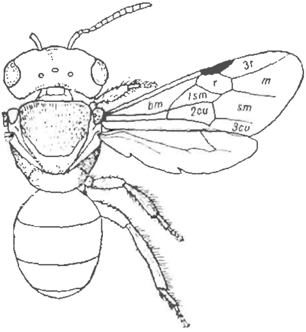


Fig. T53. *Trigona carbonaria* Sm., female, the Native Honey-Bee of Australia. Fam. Apidae. Length 4.5 mm. Lettering as in Table on p. 258, New Notation, except $m = 1m + 2m$ (in fig. T53, $m = 1m + 2m + 3m$), $r = 1r + 2r$, $sm = 2sm + 3sm$. [*E. S. Gourlay del.*

Family 66. **Apidae** (Social Bees, Honey Bees) [Aus. 9, N.Z. 0]. This family is distinguished from all the rest by the hind tibiae having no apical spurs, and by the great length of the radial cell *3r* of the forewing, which reaches almost to the apex of the wing. These bees form large social colonies or nests centred round a single large female, called the Queen-bee, the rest of the colony consisting of sterile females or workers, whose business it is to build and protect the nest and to gather the pollen and store the honey in the cells. The males, or drones, are often very numerous, but do no work. All the Australian species belong to the genus *Trigona* of the subfamily Meliponinae. They are very small bees, the worker being 4 to 6 mm. long, and build their nests in suitable holes in large forest trees. They are devoid of a sting, but have many devices for protecting their nests; these are eagerly searched for by the aborigines, who will follow one of these bees for miles to find them. The honey is stored in large quantities, but the flavour is not always very pleasant. The commonest species is *Trigona carbonaria* Sm. (fig. T53) found almost everywhere; the worker is a thick-set little blackish bee, about 4 mm. long. A good account of the habits of these bees has been given by Hockings, who states that the aboriginal name for *T. carbonaria* is "Karbi", while another species is called "Kootchar".

Of introduced species, the Honey Bee, *Apis mellifera* L., and its Italian race *ligustica* Spin., are of course abundant everywhere in Australia and New Zealand, and in many places appear to have driven away the native flower-haunting bees and wasps, owing to their habit of starting work earlier and in less bright sunshine than the latter. In New Zealand, four species of Humble-bee (*Bombus terrestris* L., *B. hortorum* L., *B. lucorum* L., and *B. ruderatus* Fabr.), were intro-

duced for the fertilization of Red Clover; but the commonest of these, *B. terrestris* L., does not possess a tongue long enough to do this. These bees have gained the objectionable habit of cutting directly into the ovaries of certain flowers to get at the nectar, and do considerable damage to broad beans.

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CHAPTER XXIII

Order NEUROPTERA

(Alder-flies, Lacewings)

This Order includes all those Endopterygote insects which possess a primitive structure of head and thorax, inclusive of complete mandibulate mouth-parts, and (except in Nemopteridae) without elongation of the head anteriorly to form a rostrum, together with either the beginnings or a complete formation of a pectinate radial sector and of small terminal twiggings of the veins. The great majority of the forms can be at once recognized by the complete series of slanting costal veinlets, by the closely parallel branches of the radial sector and by the numerous irregular cross-veins on the wings; but it should be borne in mind that both these last-named characters are really of secondary importance, and that the most primitive forms had a radial sector with only the beginnings of a pectinate formation, and scarcely any cross-veins at all. The highly reduced Coniopterygidae have none of the venational characters here mentioned, and can only be correctly classified by a study of their general morphology and life-history. Almost without exception the members of the Order sit with wings closely folded over the body in a high, roof-like manner.

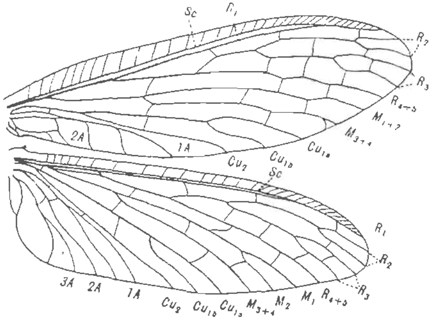


FIG. U1. Wings of *Archichauliodes dubitatus* Walk., New Zealand. Fam. Corydalidae. Length 45 mm Lettering as in fig. A8, p. 22. [*R. J. T. del.*

Characters. H e a d of variable shape, usually broader than long, with *compound eyes* widely separated; *ocelli* present or absent; *antennae* with scape, pedicel and numerous similar segments forming a medium to long flagellum, usually moniliform or filiform, sometimes pectinate,

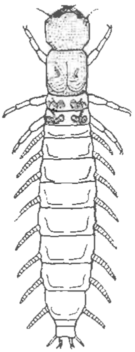


FIG. U2. Larva of *Archichauliodes dubitatus* Walk. Length 27 mm. [R. J. T. del.

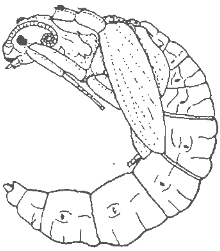


FIG. U3. Pupa of same (× 4). [R. J. T. del.

thickened or clubbed. *Mouth-parts* complete; *labrum* usually broad and entire, sometimes notched or divided in the middle; *mandibles* with strong apical tooth and usually with an inner tooth or projecting ledge; *maxillae* with lacinia, galea and 5-segmented palp; *hypopharynx* a short membranous tongue, often trilobed; *labium* with well-developed mentum and 3-segmented palpi, but with ligula poorly developed or absent.

T h o r a x of primitive form, the three segments usually very distinct from one another. *Prothorax* variable, sometimes very short or small, sometimes strong, cylindrical or elongated. *Mesothorax* always strongly developed, the mesonotum showing the primitive divisions of the scutum into three distinct parts, with a moderately formed scutellum behind; mesopleura well developed; mesosternum small. *Metathorax* similar to mesothorax, but somewhat shorter and narrower. *Legs* usually short; coxae not elongated, meron sometimes present; femora moderately stout; tibiae slender, with or without spurs; tarsi 5-segmented.

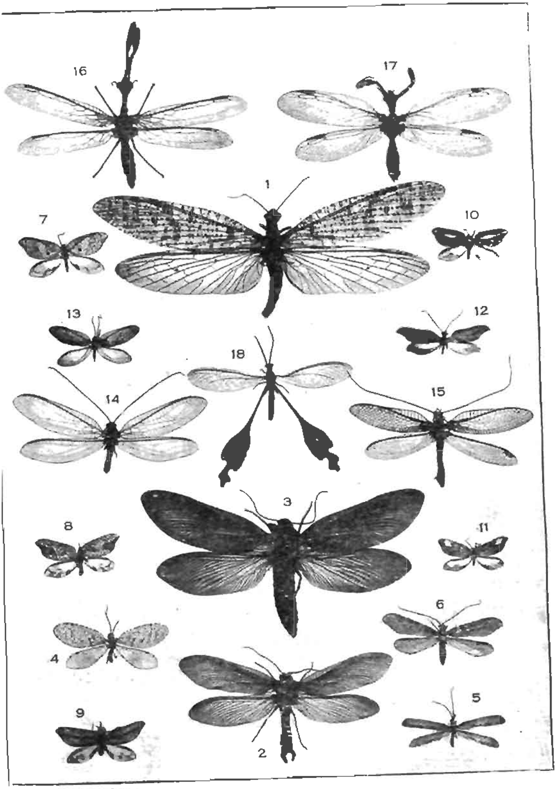
W i n g s almost always held in a high, roof-like manner above the body when at rest, and generally only capable of moderate, undulating or uneven flight; their bases always well separated; usually fore and hindwing are not connected in flight, but several families show a primitive coupling-apparatus with jugal lobe (fibula), humeral lobe and stiff frenular bristles. *Venation* (figs. U1, U8-U12, U15, U16), excessively variable, showing all stages in the development of a completely pectinate radial sector, an abundant cross-venation and a complete marginal series of tiny twiggings of the veins, often separated by

Plate 22

AUSTRALIAN AND NEW ZEALAND NEUROPTERA

All figures natural size

1. *Archichauliodes dubitatus* Walk. (Fam. Corydalidae), female. N.Z.
2. *Ithone fusca* Newm. (Fam. Ithonidae), male. Aus.
3. *Ithone fusca* Newm. (Fam. Ithonidae), female, Aus.
4. *Spermophorella maculatissima* Till. (Fam. Berothidae), female. Aus.
5. *Stenobiella hirsutissima* Till. (Fam. Berothidae), Aus.
6. *Berotha gracilipennis* Till. (Fam. Berothidae), Aus.
7. *Drepanacra binocula* Newm., type-form (Fam. Hemerobiidae), Aus. and N.Z.
8. *Drepanacra binocula* Newm., var. *instabilis* McL. (Fam. Hemerobiidae).
9. *Drepanacra binocula* Newm., var. *longitudinalis* Till. (Fam. Hemerobiidae).
10. *Drepanacra binocula* Newm., var. *bilineata* Till. (Fam. Hemerobiidae).
11. *Drepanacra binocula* Newm., var. *excisa* Till. (Fam. Hemerobiidae).
12. *Drepanomina berothoides* McL. (Fam. Hemerobiidae), Aus.
13. *Psychobiella sordida* N. Banks (Fam. Hemerobiidae), Aus.
14. *Nothochrysa insignis* Walk. (Fam. Chrysopidae), Aus.
15. *Dictyochrysa fulva* E.P. (Fam. Chrysopidae), Aus.
16. *Mantispa australasiae* Wwd. (Fam. Mantispidae), Aus.
17. *Ditaxis biseriata* Wwd. (Fam. Mantispidae), Aus.
18. *Chasmoptera hutti* Wwd. (Fam. Nemopteridae).



W. C. Davies photo.

AUSTRALIAN AND NEW ZEALAND NEUROPTERA.

marginal dots which are the sockets of stiff hairs; main veins hairy, but cross-veins seldom so, and membrane never. *Sc* a long, straight vein, with numerous costal veinlets, ending at or within the pterostigma, which is sometimes formed only by numerous, closely parallel veinlets, sometimes more or less strongly thickened; costal veinlets sometimes branched or connected by cross-bars; *the first of the series, or humeral veinlet (hm)*, sometimes a recurrent vein (fig. A21, F) with numerous branches, especially when costal space is enlarged. R_1 a strong, straight vein running close below *Sc* and often sending numerous veinlets apically into pterostigma. *Rs* arising near base and usually very highly developed as a *pectinate vein with many obliquely descending branches, but often with* R_{4+5} keeping the more primitive, dichotomic form. *M* rarely with four branches, usually reduced to three or two only, and often nearly squeezed out of existence by the over-development of *Rs*. Cu_1 a strong vein, always branched, often with a pectinate series of descending branches; Cu_2 a weak concave vein, sometimes shortened or absent. Three anal veins are present, often branched. In many forms the consecutive branches of main veins are separated by definite furrows in the membrane; of these, one between *Rs* and *M* and one between *M* and Cu_1 are most clearly defined.

A b d o m e n usually more or less cylindrical and slender (stout in Ithonidae), short or long, with ten segments; seg. 1 short, 2-8 well

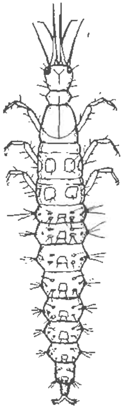


FIG. U4.

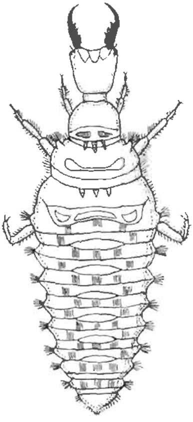


FIG. U5.

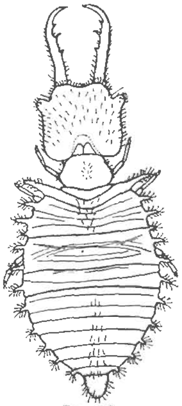


FIG. U6.

FIG. U4. Larva of *Euosmylus stellae* McL., New Zealand. Fam. Osmylidae. Length 20 mm. [*A. Tonnoir del.*

FIG. U5. Larva of *Acanthaclisis fundata* Walk., Australia. Fam. Myrmeleontidae. Length 25 mm. [*R. J. T. del.*

FIG. U6. Larva of *Suhpalacsa flavipes* Leach, Australia. Fam. Ascalaphidae. Length 10 mm. [*A. Tonnoir del.*

developed, 9 short, 10 much reduced. *Spiracles* eight pairs, on segs. 1-8. Males with a pair of superior appendages which are formed as lobes of

tenth tergite, and with one or two "inferior appendages", being either a single *hypandrium* formed from ninth sternite, or a pair of gonocoxites belonging to the same sternite; supra-anal plate and paraprocts present, often strongly developed; aedeagus weakly formed, generally mostly membranous. Females with only a single pair of gonapophyses from ninth sternite, sometimes much reduced, sometimes of considerable length, forming a distinct ovipositor, and carrying styles. *Cerci* absent. *Malpighian tubules* six or eight.

Life History. The life-histories of the two suborders Megaloptera and Planipennia agree in that the *eggs* are oval, usually with a projecting micropyle (fig. A18, C, A21, A), the *larvae* (fig. A21, B, C, U2, U4-U6) active and predatory, with well-developed thoracic legs, and the *pupae* (fig. A21, E, U3) always *pupae liberae*, capable of a considerable amount of movement. In the Megaloptera, the *eggs* are laid in large masses (Sialoidea) or singly (Raphidioidea); the larvae (fig. U2) have normal, mandibulate mouth-parts, and are either arboreal (Raphidioidea) or aquatic (Sialoidea); in the latter case a series of paired abdominal gills is present. In the Planipennia, the *eggs* are also laid singly or in masses, on leaves, twigs or bark; in several families the female deposits a sticky secretion which she draws out into a slender stalk on which the egg is placed for safety, (fig. U8, C); the *larvae* (figs. U4-U6) are mostly terrestrial or arboreal, but a few are aquatic or semi-aquatic; they are all remarkable in having the mandibles and maxillae co-ordinated to form a pair of sucking-jaws for extracting the juices of their victims, and also in having six out of their eight Malpighian tubules specialized as silk-glands; the silk-secretion is passed from the tubes into a silk-reservoir formed from part of the hind-gut, and is spun from the anus. There are four larval instars in Megaloptera, usually only three in Planipennia, (five in Ithonidae). In Megaloptera the *pupae* (fig. U3) lie free in a cell of moist earth; in Planipennia they are enclosed in a cocoon (fig. A21, D) spun from the anus of the larva; on emergence, the pupa cuts the cocoon open with its large mandibles, and often walks or climbs a considerable distance before disclosing the imago.

Distribution. The Megaloptera are very poorly represented by only three described and one undescribed species of Sialoidea in Australia and a single species in New Zealand. The other superfamily, Raphidioidea, is confined to the Northern Hemisphere. The Planipennia are abundantly represented in Australia by 250 described species, nearly 100 of which belong to the Myrmeleontidae, a family particularly suited to warm, arid conditions; the Hemerobiidae, Chrysopidae, Mantispidae and Ascalaphidae are also well represented there. Australia is the headquarters of the archaic families Ithonidae and Psychopsidae, while the Nymphidae, Myiodactylidae and Stilbopterygidae are peculiar to it and Papua. In fact, Australia has a more complete and varied fauna of Planipennia than any other region of the earth, the only absent families being the Dilaridae and Polystoechetidae. New Zealand has only a dozen Planipennia, the families represented being Hemerobiidae, Berothidae, Coniopterygidae, Osmylidae and Myrmeleontidae; it is the only large area of land of temperate climate without Chrysopidae.

Economics. The Order is almost entirely beneficial to man, the larvae of Sialoidea preying upon other aquatic larvae and also forming a valuable food for trout, while those of the Planipennia prey upon

numerous noxious terrestrial and arboreal insects. The larvae of Hemerobiidae and Chrysopidae are known as aphis-lions; these and the minute Coniopterygid larvae are amongst the most valuable allies of man in checking the spread of aphids, psyllids and scale-insects. The extraordinary larvae of Ithonidae (fig. U7), superficially resembling their prey, take a heavy toll of Scarabaeid larvae in the loose, sandy soils of Australia, while those of Myrmeleontidae, known as ant-lions, (fig. U5), capture ants and other terrestrial insects, dragging them underground and sucking them dry. Mantispid larvae (fig. U13) are parasitic in the egg-capsules of spiders. The introduction of European or North American Chrysopidae into New Zealand, without their own parasites, must, if successful, prove of great benefit in checking imported aphids and scale-insects.

Fossil History. The Megaloptera are undoubtedly a very old group, but their remains are difficult to recognize as fossils; undoubted members of the group first appear in the European Trias. The oldest known Planipennian is *Permithone belmontensis* Till (fig. ZA5) from the Upper Permian of Belmont, N.S.W.; it is ancestral to the Ithonidae and probably also to the Berothidae and allied families. The Upper Trias of Ipswich, Q., has some fine representatives of the Psychopsidae and the allied, extinct family Prohemerobiidae. *Triassopsychops superba* Till. (fig. ZA10) is closely similar in size, shape, and venation to *Megapsychops illidgei* Frogg., which exists to-day within 50 miles of where the fossil was found. The Order is also strongly represented in the European Lias and Upper Jurassic by Prohemerobiidae and the very large and handsome allied Calligrammatidae, also by a few higher types suggesting Chrysopidae and Nymphidae. A fine Osmylid wing has been found in Queensland Tertiary at Goodna.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order NEUROPTERA 254 (13)

Suborder MEGALOPTERA 4 (1)

I. SIALOIDEA 4 (1)
- 1. Sialidae 3 (0)
- 2. Corydalidae 1 (1)

[RAPHIDIOIDEA]
- (Raphidiidae)

Suborder PLANIPENNIA 250 (12)

II. ITHONOIDEA 6 (0)
- 3. Ithonidae 6 (0)

III. HEMEROBIOIDEA 106 (9)
- (Dilaridae)
- 4. Psychopsidae 12 (0)
- 5. Berothidae 8 (1)
- 6. Sisyridae 4 (0)
- 7. Hemerobiidae 16 (4)
- 8. Chrysopidae 28 (0)
- 9. Mantispidae 26 (0)
- (Polystoechetidae)
- 10. Osmylidae 12 (4)

IV. CONIOPTERYGOIDEA 12 (1)
- 11. Coniopterygidae 12 (1)

V. NEMOPTEROIDEA 4 (0)
- 12. Nemopteridae 4 (0)

VI. MYRMELEONTOIDEA 122 (2)
- 13. Nymphidae 6 (0)
- 14. Myiodactylidae 6 (0)
- 15. Myrmeleontidae 95 (2)
- 16. Stilbopterygidae 3 (0)
- 17. Ascalaphidae 12 (0)

The Order is divided into two very distinct Suborders (considered by some as two distinct Orders), as follows:—

Wing-venation with little or no end-twigging of veins, and with little extra branching of *Rs*. (In one or two genera not found in Australia or New Zealand this character does not hold). Larvae with normal mandibulate mouth-parts, six Malpighian tubules and no anal silk-glands; pupae not in a cocoon. MEGALOPTERA

Wing-venation (except in Coniopterygidae) with definite, frequently abundant, end-twigging of veins, generally also with numerous branches of *Rs*. Larvae with specialized sucking mandibles and maxillae, and eight Malpighian tubules, six of which are specialized to form the anal silk-glands; pupae in a cocoon. PLANIPENNIA

Suborder MEGALOPTERA

This is a small group containing under 200 species throughout the world. It includes two very distinct superfamilies, Sialoidea, known as Alder-flies in England, Dobson-flies in America, and Raphidioidea, or Snake-flies. The latter do not occur in Australia or New Zealand. The following Key distinguishes the two groups:—

Prothorax not greatly elongated. *Sc* long, fused distally with R_1; larvae aquatic. I. SIALOIDEA

Prothorax forming an elongated neck. *Sc* shorter, not fused with R_1 distally; larvae arboreal. [RAPHIDIOIDEA]

Superfamily I. SIALOIDEA

These are sluggish insects found only in the neighbourhood of fresh-water streams; they fly mostly only late in the day or after dusk. There are two distinct families, both found in Australia, but only the Corydalidae in New Zealand:—

Small insects expanding less than an inch; forewing with *M* and Cu_1 fused for a space below level of origin of *Rs*. Larvae with abdomen ending in a single, elongated sucker. Fam. 1. SIALIDAE

Much larger insects expanding 2 to 4 inches; forewing with *M* and Cu_1 quite separate. Larvae with last abdominal segment provided with a pair of hook-bearing processes. Fam. 2. CORYDALIDAE

Family 1. **Sialidae** (Alder-flies) [Aus. 3, N.Z. 0]. The Australian species are all very rare insects, the handsomest being *Austrosialis ignicollis* Till. from Tasmania, about 20 mm. in expanse, with black body and wings and bright orange prothorax. *Stenosialis*, with narrower wings, has one species in Queensland. A smaller and duller species (undescribed) occurs near Sydney.

Family 2. **Corydalidae** (Dobson-flies) [Aus. 1, N.Z. 1]. This fine family is represented by a single genus, *Archichauliodes*. *A. dubitatus* Walk. (fig. U1 and pl. 22, fig. 1) is abundant on all running rivers in New Zealand. It is a large insect, the male expanding 2 to 2½ inches, the female 3 to 4 inches, greyish, with pale semi-transparent wings and spotted venation. The larva (fig. U2) is a cylindrical grub, fiercely carnivorous, found under rocks in streams, and known as the "Toe-biter"; it is a splendid food for trout. The pupae (fig. U3) are not uncommon under rocks edging the streams. The Australian species *A. guttiferus* Walk. is not so common, and varies greatly in colour; the lowland forms have large black spots or blotches on the wings, while the mountain forms closely resemble the New Zealand species.

Suborder PLANIPENNIA

This Order contains the Lacewings, Ant-lions and allies. There are 16 families known, of which no less than 14 are found in Australia, but only five in New Zealand. They may be divided into five superfamilies, as follows:—

1. Large, stoutly built, moth-like insects expanding 30-50 mm., with primitive, unspecialized venation; head small and closely applied to prothorax; larva a burrowing grub of melolonthoid form; cocoon elongate-cylindrical with rounded ends. II. ITHONOIDEA

Not such insects. 2

2. Very small insects, expanding 3 to 10 mm., of slender build; wings covered with a mealy pubescence, usually white or pale greyish; venation with only two branches to *Rs* and no terminal twigging.
IV. CONIOPTERYGOIDEA
Not such insects. 3
3. Hindwings greatly elongated, ribbon-like or spoon-shaped; larva with a long neck. V. NEMOPTEROIDEA
Hindwings not as above; larva without a long neck. 4
4. Antennae moniliform or filiform; Cu_1 mostly without a diverging posterior branch; larvae more or less elongated, with mandibles devoid of internal teeth. III HEMEROBIOIDEA
Antennae stoutly cylindrical, or with apex thickened or clubbed; Cu_1 mostly with a strong, diverging posterior branch; larvae very broad, its mandibles with one or more internal teeth.
VI. MYRMELEONTOIDEA

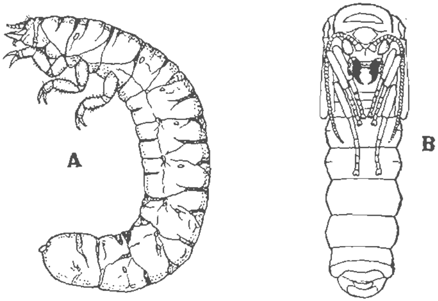


FIG. U7. *Ithone fusca* Newm., Australia. Fam. Ithonidae. A, larva. Length 30 mm. B, pupa, ventral view, showing mandibles (in black). Length 25 mm. (*R. J. T. del.*

Superfamily II. ITHONOIDEA

This group includes only the single family Ithonidae or Moth-Lacewings. Apart from Australia, this ancient group is only represented by the genus *Kapisma* in the Himalayas and *Oliarces* in California.

Family 3. **Ithonidae** (*Moth-Lacewings*) [Aus. 6, N.Z. 0]. This family contains three Australian genera. The males have large, forcipate appendages; the females are larger and carry a peculiar sand-plough, which they use for laying their eggs in sandy soil, rolling each into a small cocoon of sand-grains. The larvae (fig. U7) closely resemble those of Scarabaeidae in form, but have small heads without eyes, and strong burrowing legs; they emit a strong, pleasant odour of citronella. The sucking jaws are short and triangular, upcurving, with the maxilla more strongly formed than the mandible. They attack Scarabaeid larvae and other insect grubs in the soil, and are therefore of economic value; unfortunately, attempts to introduce them into other countries have so far failed. *Ithone fusca* Newm. (pl. 22, figs. 2, 3) is common in the sandy coastal lands of New South Wales; the forewing has only a single *Rs*. *Heterithone*, with three species, differs in having two apparent *Rs* in forewing; it occurs from Queensland to Tasmania. *H. megacerca* Till. is a fine species with huge appendages in the male. *Varnia*, with speckled venation, is confined to Western and Central Australia.

Superfamily III. HEMEROBIOIDEA

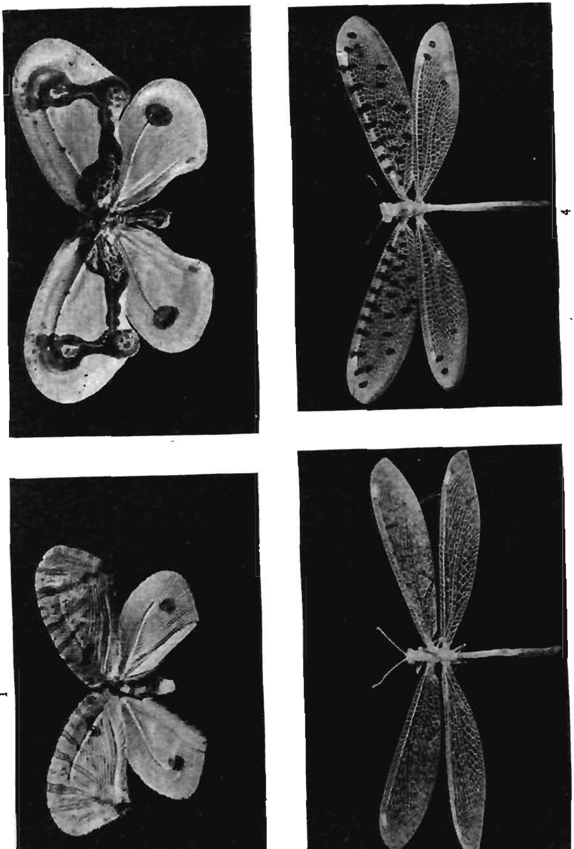
This group includes all the smaller lacewings except Coniopterygidae, together with a few of larger size, all united by the primitive, moniliform or filiform

Plate 23

AUSTRALIAN NEUROPTERA

All figures natural size

1. *Psychopsis mimica* Newm. (Fam. Psychopsidae).
2. *Megapsychops illidgei* Frogg. (Fam. Psychopsidae).
3. *Xantholeon helmsi* Till. (Fam. Myrmeleontidae).
4. *Callistoleon erythrocephalus* Leach (Fam. Myrmeleontidae).



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antennae. The larval jaws are mostly short and somewhat curved, but those of the Psychopsidae have large, calliper-like jaws (fig. A21, B, C), while those of the Osmylidae (fig. U4) have long, slender, piercing spears. Most of the larvae are arboreal, but those of some Osmylidae are semi-aquatic, lurking under wet rocks near running streams, while those of the Sisyridae are entirely aquatic. The imagines, especially Psychopsidae and Chrysopidae, are attracted to light. The seven families may be separated as follows:—

1. Forewing with at least two apparent radial sectors. Fam. 7. HEMEROBIIDAE
   Forewing with only a single *Rs*. 2
2. Medium to large species having forewings very broadly rounded apically, the costal area very broad, and a true *vena triplica* formed by Sc_1, R_1 and *Rs*, ending well before apex. Fam. 4. PSYCHOPSIDAE
   Not such insects. 3
3. Medium to large species having the wings divided into an inner discal area containing irregular cross-veins and an outer marginal area free of cross-veins; *Sc* fused distally with R_1. Fam. 10. OSMYLIDAE
   Not such species (if, as rarely happens, *Sc* is fused distally with R_1, then no discal area is present, and vice versa). 4
4. Very small species with cross-vein *r-m* in hindwing long and placed longitudinally; larvae aquatic, feeding on fresh-water sponges. Fam. 6. SISYRIDAE
   Not such species; *r-m* of hindwing short and normally placed. 5
5. Cu_1 in hindwing runs for a long distance close to hind border. Fam. 5. BEROTHIDAE
   Cu_1 not as above. 6
6. Antennae short; prothorax long, forelegs strong, raptorial; wings usually narrow and with only one gradate series of cross-veins (two in *Ditaxis*); eyes dull; species usually of reddish or brown colour. Fam. 9. MANTISPIDAE
   Antennae long to very long; prothorax and forelegs normal; wings not so narrow as above, and with at least two gradate series of cross-veins; eyes brightly metallic; species of green or yellowish colour. Fam. 8. CHRYSOPIDAE

Family 4. **Psychopsidae** (Silky Lacewings) [Aus. 12, N.Z. 0]. Antennae short, moniliform; head depressed, hidden beneath the bases of the greatly enlarged costal areas of forewings, which carry numerous branching veinlets often connected with cross-bars, and a strong recurrent vein (fig. A21, F). *Rs* with very numerous, closely parallel branches. Cross-veins mostly in 1, 2 or 3 gradate series; veins with numerous silky hairs. Larvae (fig. A21, B, C) elongate, somewhat broad and flattened, covered with greyish pubescence, and having large, calliper-like jaws; they live under the bark of rough-barked eucalypts, especially Blood-wood, Tallow-wood and Ironbark. Pupae (fig. A21, D, E) in a pearl-like, spherical cocoon. A very ancient family existing almost unchanged since Triassic times, and with its headquarters in Australia; a few species occur in Africa, India and China. Nearly all the species are of striking beauty. Twelve of them belong to the dominant genus *Psychopsis*, of which the type is the lovely *Ps. mimica* Newm. (pl. 23, fig. 1) with pinkish fasciae on forewings. *Ps. elegans* Guer. (pl. 11, fig. 19 and fig. A21, F) occurs along the Eastern coast-line. *Ps. coelivagus* Walk. is a smaller species found in Queensland, pure white, heavily marked with metallic bronze-black. *Ps. insolens* McL., the commonest species, has mottled, fawn-coloured wings. *Psychopsella gallardi* Till. is a small, delicate species with narrow hindwings. The finest and rarest species of all is *Megapsychops illidgei* Frogg., (pl. 23, fig. 2), expanding 2½ to 3 inches and with raised embossments and marks resembling brown varnish on the forewings; when at rest, this insect simulates a reptilian head. It occurs very rarely at Mount Tambourine and one or two other places in S. Queensland.

Family 5. **Berothidae** [Aus. 8, N.Z. 1]. A small family of six scattered genera, three of which occur in Australia and one in New Zealand. The most interesting are the two species of *Spermophorella*, expanding about 15 mm., with well-rounded wings. The females have a patch of hard, seed-like scales near middle of hindwings. *S. disseminata* Till. (fig. U8) lives in sandstone caves around Sydney, and lays stalked eggs; the larvae have short, straight jaws. *S.*

maculatissima Till. (pl. 22, fig. 4) is a darker species found in S. Queensland. The two species of *Stenobiella* (pl. 22, fig. 5) have exceedingly long, narrow wings, obliquely truncated at tips. *Berotha* (pl. 22, fig. 6) has falcate wings. The New Zealand species, *Protobiella zelandica* Till. has Cu_1 less lengthened than usual. In this family alone of all Planipennia Sc and R_1 are sometimes fused, sometimes separate.

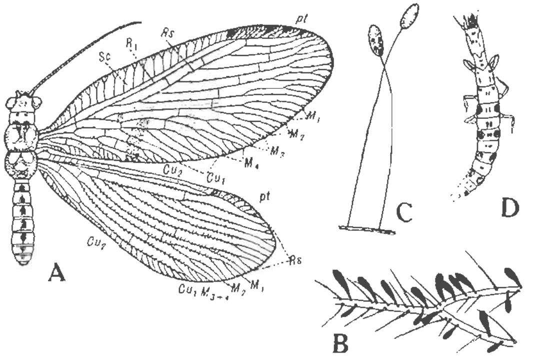


FIG. U8. A. *Spermophorella disseminata* Till., female, Australia. Fam. Berothidae. Length of forewing 13 mm. Lettering as in fig. A8, p. 22, except *pt*, pterostigma; B, a few of the hard, seed-like scales on the hindwing, enlarged (× 60); C, stalked egg of same species (× 8); D, newly hatched larva of same species (× 22). [*R. J. T. del.*

Family 6. **Sisyridae** (Spongilla-flies) [Aus. 4, N.Z. 0]. These tiny brown or fuscous insects resemble small Hemerobiids, but have Sc and R_1 fused distally, very few cross-veins, with no gradate series, forewing with a single Rs with three or four branches only, hindwing with *r-m* lengthened (fig. U9). The

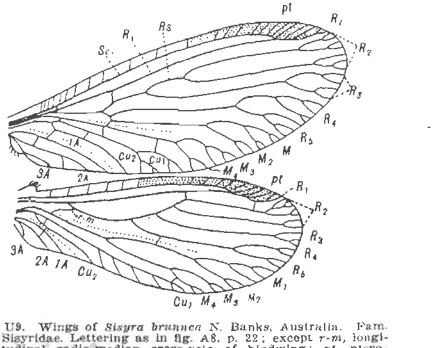


FIG U9. Wings of *Sisyra brunnea* N. Banks, Australia. Fam. Sisyridae. Lettering as in fig. A8, p. 22; except *r-m*, longitudinal radio-median cross-vein of hindwing; *pt*, pterostigma. [*R. J. T. del.*

larvae are aquatic, feeding on freshwater sponges; they have long, hair-like jaws, and the abdomen carries a series of paired, segmented appendages resembling legs. Pupae in a delicate, double cocoon above water-level. The Australian species all belong to *Sisyra*, the best known being *S. brunnea* N. Banks (fig. U9).

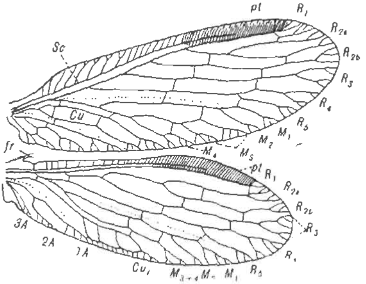


FIG U10. Wings of *Micromus tasmaniae* Walk., Australia and New Zealand. Fam. Hemerobiidae. Note the three apparent *Rs* on forewing. Lettering as in previous figure; except *fr*. frenulum. (*R. J. T. del.*

Family 7. **Hemerobiidae** (Brown Lacewings) [Aus. 16, N.Z. 4]. Small species, mostly with brown or spotted wings, always with at least two apparent *Rs* in forewing. Hindwing with *r-m* long and placed longitudinally, as in Sisyridae. Eggs laid singly, not stalked. The larvae are fusiform or subcylindrical, with short jaws, and feed ravenously on the smaller Homoptera, especially aphids and psyllids; the family is highly beneficial to mankind. Cocoon oval. The Australian Hook-tip Lacewing, *Drepanacra binocula* Newm. (pl. 22, figs. 7-11) equally common also in New Zealand, Lord Howe and Kermadec Islands, is one of the most variable of all lacewings, and its varieties have been described under many names; the commonest forms are var. *humilis* McL. and var. *instabilis* McL.

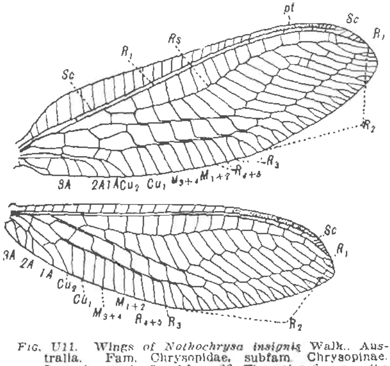


FIG. U11. Wings of *Nothochrysa insignis* Walk., Australia. Fam. Chrysopidae, subfam. Chrysopinae. Lettering as in fig. A8, p. 22. The veins forming the pseudomedia and pseudocubitus are slightly separated, so as to show the true structure of those

(pl. 22, fig. 8); the type form, with a black eye-spot on forewing, is very rare. All forms have been reared from a single brood feeding on young psyllids on *Acacia decurrens*. *Drepanomina berothoides* McL. (pl. 22, fig. 12) is a rarer insect with a hump on costa of forewing. *Micromus* is represented by two species in Australia and two in New Zealand. *M. tasmaniae* Walk. (fig. U10) is the most useful and abundant lacewing in both countries, and does good work in gardens and orchards, its larvae destroying introduced scales and aphids. Other genera are *Boriomyia* in New Zealand, *Megalomus*, *Psychobiella* (pl. 22, fig. 13), *Oxybiella*, *Notiobiella* and *Carobius* in Australia; the last-named contains very small, prettily marked species with only two apparent *Rs* in forewings (subfamily Sympherobiidae); the other genera have three or more (subfamily Hemerobiinae).

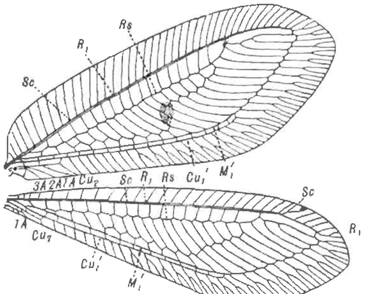


FIG. U12. Wings of *Oligochrysa gracilis* E. P., Australia. Fam. Chrysopidae, subfam. Apochrysinae. Lettering as in previous figure, except Cu_1', pseudocubitus; M', pseudomedia. [*R. J. T. del.*

Family 8. **Chrysopidae** (Green Lacewings, Golden Eyes, Stink-flies) [Aus. 28, N.Z. 0]. The vernacular names are given from the prevailing green colour, from the brilliantly metallic, usually golden or coppery eyes, and from the fact that a number of the species emit a very unpleasant odour when handled. Antennae long, filiform. Wings with *2* or *3* gradate series of cross-veins, and having the branches of *Rs* peculiarly zig-zagged, so as to form, in combination with *M* and Cu_1, a pair of straight longitudinal veins called the *pseudomedia* (M') and *pseudocubitus* (Cu_1'). Eggs laid on long, slender stalks. Larvae very similar to those of Hemerobiidae, but usually with abdomen stouter in the middle; some species cover themselves with the débris of dead aphids or coccids. Cocoon spherical, pearl-like. A highly beneficial family, absent from New Zealand. The dominant genus in Australia, as elsewhere, is *Chrysopa*, with numerous species, many of which have not yet been described; six species are known from Norfolk Island. The species are closely allied and difficult to distinguish; *Ch. signata* Walk. appears to be the commonest. *Nothochrysa* contains several larger species, yellowish in colour, *N. insignis* Walk. (pl. 22, fig. 14) being the best known species. *Ankylopteryx* includes a few small species with broadened costal area in forewing. *Dictyochrysa* (pl. 22, fig. 15) is a remarkable genus, confined to Australia, in which the whole wing is filled with a meshwork of polygonal cells. The very distinct subfamily Apochrysinae, considered by some as a separate family, is represented by the genus *Apochrysa* in Papua and by *Oligochrysa gracilis* E. P. (fig. U12) in Eastern Australia; this insect is an exceedingly delicate, gauzy green lacewing, with very long, slender antennae, and enlarged costal area in forewing.

Family 9. **Mantispidae** [Aus. 26, N.Z. 0]. These extraordinary lacewings superficially resemble the Orthopterous Mantidae, with which they agree in the form of the head and antennae, the elongate prothorax, and the peculiar

raptorial forelegs. The venation comes closest to that of Chrysopidae, but there is no formation of *M'* or *Cu'*, and, except in *Ditaxis* (pl. 22, fig. 17), only one gradate series of cross-veins; the wings are usually long and narrow, and the gradate series more longitudinally placed than in Chrysopidae. The eggs are

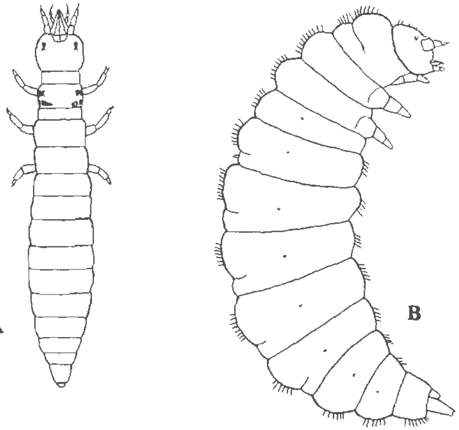


FIG. U13 (left to right). A, newly hatched larva of *Mantispa vittata* Guer. (× 90); B, same larva at beginning of third instar (× 20). [*R. J. T. del*

minute, laid in masses on tiny stalks, so as to resemble the fructifications of a clump of moss. From the egg a tiny Hemerobiid-like larva (fig. U13, A) emerges, which perishes unless it finds a spider's egg-capsule; the larva burrows through the silk and feeds on the spider's eggs, swelling out very quickly into a fat cream-coloured maggot with head and legs lost in the stout body. There are three instars, during which the head and legs fail to develop *pari passu* with the greatly swollen body; thus the full-fed larva is a large maggot with small, useless legs and a tiny head with small, sharp, sucking jaws (fig. U13, B). Cocoon of coarse yellow silk, usually spun within the spider's egg-capsule. This family is well represented in Australia, the commonest forms being the reddish-brown species of *Mantispa* and *Austromantispa*; the finest of these is *Mantispa australasiae* Wwd. (pl. 22, fig. 16), measuring up to 2 inches in expanse; the larva feeds in the egg-capsules of large Lycosid spiders. *M. strigipes* Wwd. and *M. vittata* Guer. are common species of smaller size. *Calomantispa spectabilis* N. Banks is a beautiful little species with a red and black patch at base of wings, found in Tasmania and Eastern Australia. *Euclimacia* contains two handsome, wasp-like species with a narrow waist and banded wings. *Ditaxis biseriata* Wwd. (pl. 22, fig. 17) is a large brown species from 1 to 2 inches in expanse, the wings pinkish with two gradate series; it occurs in South Queensland. This genus is closely allied to the South American *Drepanicus*.

Family 10. **Osmylidae** [Aus. 12, N.Z. 4]. These graceful insects are distinguished by the slender, filiform antennae, not as long as in Chrysopidae, and the wings having *Sc* and *R*$_1$ fused distally, the area below them divided into an inner disc, with numerous irregular cross-veins, and an outer marginal area free from cross-veins; undoubtedly a single gradate series (as in the American family Polystoechetidae) separated these two areas originally, and the inner cross-veins developed later on. The eggs are not stalked; the larvae (fig. U4) are long and

slender, with elongated, spear-like jaws. The more typical forms have semi-aquatic larvae, usually shining black, which lurk under rocks in wet places bordering streams. Cocoon flattish, soft, unsymmetrical. *Stenosmylus* is represented by several species in Australia, *S. tasmaniensis* Kruger being the best known, and by the rare *S. latiusculus* McL. (pl. 24, fig. 1) in New Zealand. *Eidosmylus* and *Oedosmylus* contain smaller and more delicate Australian species, all these are brownish or greyish in colour, sometimes with speckled wings *Euosmylus stellae* McL. (pl. 2, fig. 21) is a smaller, rather short-winged species found in New Zealand, very variable in wing-pattern, ranging from yellow to dark brown with all kinds of markings. *Kempynus* is a New Zealand genus with two fine and beautifully marked species in which the wings are somewhat falcate; *K. incisus* McL. is common, *K. citrinus* McL. much rarer. The Australian subfamily Porisminae contains species with arboreal larvae living under bark like those of Psychopsidae. *Porismus strigatus* Burm. (pl. II, fig. 20) is a lovely black and yellow species, often found resting on or flying around eucalypts in April; it is the commonest Australian Osmylid. *Euporismus albatrox* Till. (pl. 24, fig. 2) is a much larger, black and white species, very handsome, found in South Queensland.

Superfamily IV. CONIOPTERYGOIDEA

These tiny insects, mostly from 3 to 5 mm. in expanse, resemble the Aleurodidae or "Snow-flies" in having the wings covered with a white or greyish meal. The general morphology and life history prove them to be Planipennia, though the wings have only a two-branched *Rs* and no end-twigging. They have tiny, pink, fusiform larvae which attack larval psyllids, and are usually found hiding in the growing tips of twigs of infected trees and shrubs, especially wattles. There is only one family.

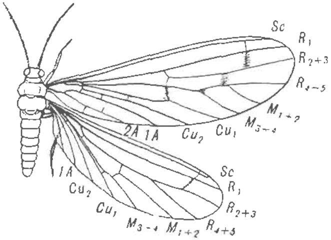


FIG. U14. *Spiloconis maculata* End., Australia. Fam. Coniopterygidae. Lettering as in fig. A8, p. 22. Length of forewing 4.5 mm. [*A. Tonnoir del.*

Family 11. **Coniopterygidae** [Aus. 12, N.Z. 1]. New Zealand has one undescribed species belonging to *Helicoconis*. In Australia *Parasemidalis* is the most abundant genus, *P. farinosa* McL. the commonest species. Other genera are *Heteroconis, Helicoconis* and *Spiloconis*. *S. maculata* End. (fig. U14) is the largest species, expanding up to 10 mm., white with three dark spots on forewing.

Superfamily V. NEMOPTEROIDEA

A group of extraordinary lacewings, in which the head is prolonged forwards into a rostrum, the antennae are short, cylindrical and thickened, and the first segment of the abdomen is closely united with the thorax. The hindwing is remarkably specialized, being excessively long and narrow, either ribbon-like, or with one or two expanded parts, more or less spoon-shaped, and twisted round upon itself between the expansions. The forewing has a primitive Myrmeleontoid type of venation. Larvae dwelling in sand or débris, with stout body, long slender neck, calliper-like jaws with or without internal teeth. There is only one family, Nemopteridae, confined to Africa, Madagascar, South Europe to India, and Western Australia across to N. Queensland.

Family 12. **Nemopteridae** [Aus. 4. N.Z. 0]. The family is divided into the Nemopterinae or Spoon-winged Lacewings and the Crocinae or Thread-winged Lacewings. The former are represented in Western Australia by the rare *Chasmoptera hutti* Wwd. (pl. 22, fig. 18), and by the larger and paler *Ch. superba* Till. The Crocinae are represented by *Croce attenuata* Frogg. in Central Australia and N. Queensland, and by an undescribed genus in Western Australia

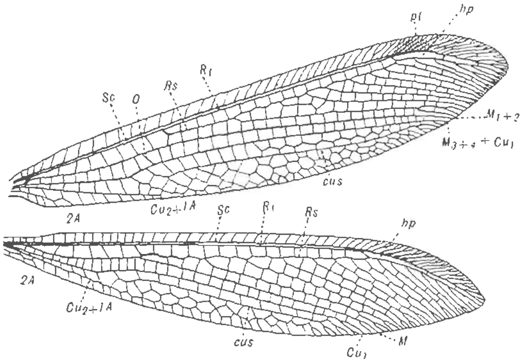


FIG. U15. Wings of *Myrmeleon uniseriatus* Gerst., Australia. Fam. Myrmeleontidae, subfam. Myrmeleontinae. Lettering as in fig. A8, p. 22; except *hp*, hypostigmatic cell; *O*, oblique vein indicating point of fusion of M_{3+4} with Cu_1. [*R. J. T. del.*

Superfamily VI. MYRMELEONTOIDEA

This great group, dominant within the Order, appears to have arisen in the Jurassic from the same stem as the Osmylidae. The antennae are thickened, cylindrical, apically swollen or clubbed. The wings are either completely reticulate or retain the Osmylid character of a division into a reticulate disc and an open marginal area; they usually show further specialization in the region of *Rs*, *M* and *Cu*, and the anal veins become much reduced. Larvae (figs. U5, 6) always stout-bodied, often very rounded, with lateral processes; jaws very large, curved apically, with at least one internal tooth on each mandible. Cocoon spherical. There are five families, all found in Australia and three of them confined to Australia and Papua. Only the Myrmeleontidae occur in New Zealand. The hypostigmatic cell (figs. U15, 16 *hp*), below the fused ends of *Sc* and R_1, is of importance in classification. The families are separated as follows:—

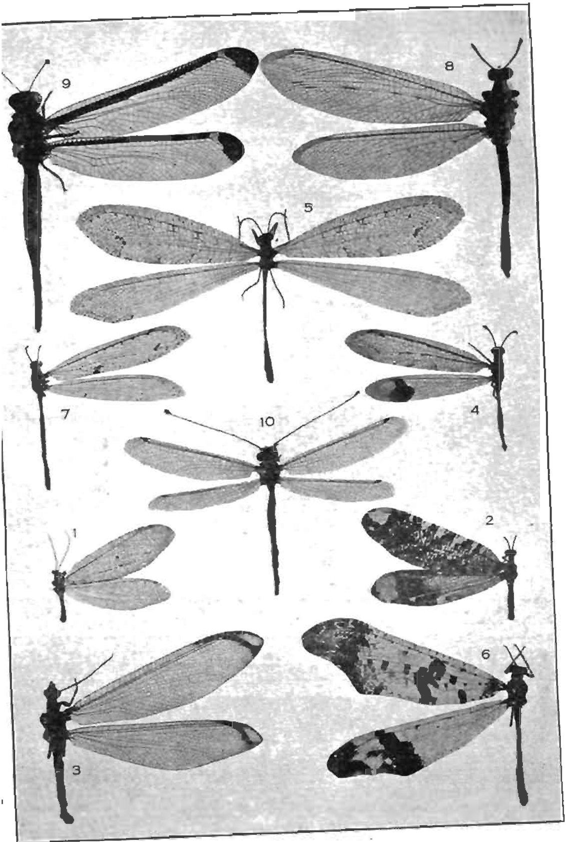
1. Area between *Sc* and R_1 with numerous cross-veins; antennae cylindrical, without any terminal thickening; larval mandibles with only one internal tooth. 2
   Area between *Sc* and R_1 devoid of cross-veins; antennae always either swollen, flattened or strongly clubbed at apex; larval mandibles with at least three internal teeth. 3
2. Wings long and narrow; Cu_1 with diverging branches; forewing with narrow costal space; hindwing with *M* simple. Fam. 13. NYMPHIDAE
   Wing broader, with wide costal space in forewing; Cu_1 without diverging branches; hindwing with *M* forked near base. Fam. 14. MYIODACTYLIDAE
3. Antennae short. 4
   Antennae long, ending in a strong club; no elongated hypostigmatic cell present. Fam. 17. ASCALAPHIDAE

PLATE 24

AUSTRALIAN AND NEW ZEALAND NEUROPTERA

All figures natural size

1. *Stenosmylus latiusculus* McL. (Fam. OSMYLIDAE), N.Z.
2. *Euporismus albatrox* Till. (Fam. OSMYLIDAE), Aus.
3. *Nymphes myrmeleonides* Leach (Fam. NYMPHIDAE), Aus
4. *Glenoleon falsus* Walk. (Fam. MYRMELEONTIDAE), Aus.
5. *Mossega indecisa* N. Banks (Fam. MYRMELEONTIDAE), Aus.
6. *Periclystus circuiter* Walk. (Fam. MYRMELEONTIDAE), Aus.
7. *Myrmeleon acutus* Walk. (Fam. MYRMELEONTIDAE), N.Z.
8. *Acanthaclisis fundata* Walk. (Fam. MYRMELEONTIDAE), Aus.
9. *Stilbopteryx napoleo* Lefèbre (Fam. STILBOPTERYGIDAE), Aus.
10. *Suhpalacsa flavipes* Leach (Fam. ASCALAPHIDAE), Aus.



W. C. Davies photo.

AUSTRALIAN AND NEW ZEALAND NEUROPTERA

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4. Antennae strongly clubbed; hypostigmatic cell variable in form; large, strongly built, swift-flying species with smooth, shiny wings and abdomen. Fam. 16. STILBOPTERYGIDAE
Antennae weakly clubbed or flattened at tips; hypostigmatic cell elongated, without cross-veins; less strongly built species with downy or hairy wings and bodies. Fam. 15. MYRMELEONTIDAE

Family 13. **Nymphidae** [Aus. 6, N.Z. 0]. A small family confined to Australia and Papua. The only common species is the well-known *Nymphes myrmeleonides* Leach (pl. 24, fig. 3), a beautiful, orange-brown insect, with strong musk-like odour, found in most parts of Australia. Eggs laid on long, slender stalks, under logs, débris, etc. Larvae stout, much like an ant-lion in shape, but very sluggish, dull brown in colour, lurking under logs or in débris; mandibles large and curved, as in ant-lions, but with only one internal tooth. Cocoon spherical, yellowish-brown, anchored to underside of logs, or under loose bark, by a stout silken thread. Other genera are *Austronymphes* and *Nymphidrion*.

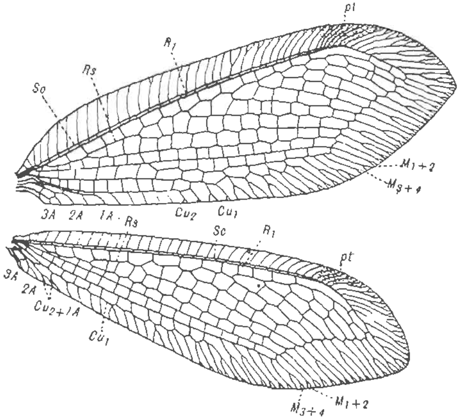

FIG. U16. Wings of *Osmylops pallidus* N. Banks, Australia. Fam. Myiodactylidae. Lettering as in fig. A8, p. 22. Length of forewing 23 mm. [*R. J. T. del.*

Family 14. **Myiodactylidae** [Aus. 6, N.Z. 0]. A small family found only in Australia, Papua and Lord Howe Island. These insects closely resemble Osmylidae, but have broader wings and thicker and shorter antennae. *M* is simple in forewing, two-branched in hind. Their larvae (fig. U17) are entirely different from those of Osmylidae, being extraordinary, flattened, circular, disc-like creatures of a bright green colour, with complex lateral processes; the long curved mandibles have a single internal tooth; the jaws are held wide apart at an angle of more than 180°, ready to snap at any insects that comes within reach. These larvae hide on the underside of leaves of eucalypts and other plants. Eggs laid on long stalks, hanging downwards. Cocoons of soft pale silk, nearly spherical. There are two genera, *Myiodactylus*, found in tropical Australia and Lord Howe Island, with very reticulate costal area, and *Osmylops* (fig. U17), which extends from the tropics down into New South Wales and Victoria. *O. pallidus* Banks (fig. U16) is a delicate, greenish species found round Sydney and Brisbane.

Family 15. **Myrmeleontidae*** *(Ant-lion Lacewings) [Aus. 95, N.X. 2]*. This family, which is the dominant one of the Order, is perhaps better known *from its familiar larval forms*, called "ant-lions" (fig. U5), rather than from the slender, delicate, adult lacewings. The larvae are stout-bodied, with large

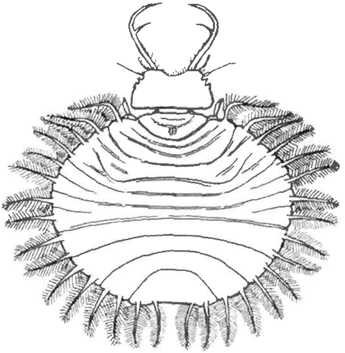

FIG. U17. *Larva of Osmylops pallidus* N. Banks. Length 6·5 mm. Jaws moved into forward position to show structure.
[*A. Tonnoir del.*

jaws curved inwards apically and having at least three internal teeth on each mandible. Most of them live hidden in sand or débris. Of all the Australian genera, only the larvae of *Myrmeleon* and *Callistoleon* are known to make conical pits in sand to snare their prey. Cocoon spherical, covered with sand. The imagines have short, feebly clubbed or flattened antennae, and long, narrow wings, with *Sc* and R_1 fused apically and a long, open, hypostigmatic cell (fig. U15. *hp*) present. M_{3+4} in forewing is fused with Cu_1, its free basal piece being represented by an oblique vein (fig. U15, *O*). There are 36 genera in Australia, the family being particularly well represented in the arid regions of Western and Central Australia. Most of the genera and species belong to the subfamily Dendroleontinae, in which there is only a single cross-vein before the origin of *Rs* in hindwing. The dominant genera are *Glenoleon* and *Formicaleo*, each with about a dozen species. *G. pulchellus* Ramb., with two dark blotches on hindwing, is perhaps the commonest member of the family in Australia, but its life-history is quite unknown; the allied *G. falsus* Walk. (pl. 24, fig. 4) and *G. meteoricus* Gerst. have the hindwings with only one dark blotch. *Mossega indecisa* N. Banks (pl. 24, fig. 5) is a delicate, very beautiful species with speckled wings, the hind pair rather elongate. The three species of *Periclystus* are extremely handsome lacewings with falcate wings. *P. circuiter* Walk. (pl. 24, fig. 6) and *P. laceratus* Gerst. from Eastern Australia, expand up to 4 inches, with forewings marked and banded with purplish-black; *P. aureolatus* Till. (pl. 11, fig. 21) is a rare West Australian species of smaller size, with rich golden areas on the forewings. The allied *Froggattisca pulchella* E. P. is also a beautifully marked insect. *Formicaleo* and *Pseudoformicaleo* contain a number of closely similar species with long, slender, speckled wings, occasionally with small black spots or blotches; *F. vafer* Walk., *F. canifrons* Nav. and *F. breviusculus* Gerst. are the commonest species. The genus *Protoplectron* contains five rather rare, handsome species with speckled wings, in which Cu_{1b} runs more parallel to Cu_{1a} than usual in this family and costal space of forewing has two rows of cells. *Eidoleon bistrigatus* Ramb., with long, pointed wings and a black longitudinal stripe on hindwings, is very common in Eastern Australia; in Western Australia it is replaced by the hand-

somer *E. nigrosignatus* Till. *Xantholeon helmsi* Till. (pl. 23, fig. 3) is an extraordinary species which lives in sandstone caves around Sydney and is protectively coloured; its larva, also sand-coloured, lives in the sand on the floor of the caves.

The subfamily *Myrmeleontinae* has several cross-veins before the origin of *Rs* in the hindwing. Twenty species are known in Australia, nine belonging to *Myrmeleon*, the larvae of which are the common, pit-forming ant-lions. *M. pictifrons* Gerst. and *M. uniseriatus* Gerst. (fig. U15) are both very common in Eastern Australia; their pits are to be found everywhere in sand in the bush, and are abundant also under houses. *M. croceicollis* Gerst. is a fine species from Northern Australia, grey with a yellow prothorax. The New Zealand Antlion, *M. acutus* Walk. (pl. 24, fig. 7) is a handsome species, very variable in the amount of spotting of the wings; on account of its having usually two rows of cells in the basal part of the costal space of forewing, Navas has placed it in a distinct genus *Weeleus*; but unfortunately many specimens lack this character entirely. The two species of *Callistoleon*, *C. erythrocephalus* Leach (pl. 23, fig. 4) and *C. illustris* Gerst. are very beautiful insects with white venation and large black spots on the wings; they also have pit-forming larvae, but are not very common. *Acanthaclisis* and its allies, *Mestressa* and *Cosina*, include ten species of large size with a double row of cells throughout the costal space of forewing; their huge larvae (fig. U5) form no pits, but lurk under débris or loose soil at the base of trees. *A. fundata* Walk. (pl. 24, fig. 8), a handsome grey and whitish insect with a very hairy body and an expanse of 3½ to 4½ inches, occurs all over Australia. *A. fulva* E. P. and *A. peterseni* Till. are very large, orange-brown species expanding up to 7 inches. The beautiful *Cosina maclachlani* Weele and *C. annulata* E.P. come from the central desert belt of Australia; Navás has also described *C. neozelandica* Nav. from New Zealand. Most of the species fly at night or in the evening; a few come to light.

Family 16. **Stilbopterygidae** [Aus. 3, N.Z. 0]. These fine insects, confined to Australia, closely resemble true Ascalaphidae, but differ from them in having very short antennae, and in the variable condition of the hypostigmatic cell, which, in some individuals, closely approximates to the long, open cell of the previous family. The larvae are huge, black, rugose creatures with round, somewhat flattened bodies, spiny lateral processes, large head and immense jaws; they live in débris on the ground. The imagines fly at dusk with great speed, high up in the air in clearings in the bush; unlike dragonflies, they have no power to dodge or turn quickly, and can be caught merely by interposing a net in their path. *Stilbopteryx costalis* Newm. occurs in Eastern Australia, *S. napoleo* Lefébre (pl. 24, fig. 9) in Western Australia; both are rare insects. *S. linearis* Nav. is a doubtful species.

Family 17. **Ascalaphidae** [Aus. 12, N.Z. 0]. These beautiful insects are perhaps the most highly developed of all Planipennia. They are diurnal insects with a strong, musk-like odour, and, like their analogues the Butterflies, have developed long, knobbed antennae. They generally rest with wings drooping obliquely below abdomen. Their hard, oval eggs are laid transversely in masses around twigs or grass-stalks, 50-100 together, and are frequently met with in the bush. The young larvae, with huge heads and jaws, sit close together on the egg-shells, all combining to capture an unwary insect; but as soon as one of them reaches the second instar it becomes a cannibal, and many of its brothers fall victims to it. The larvae (fig. U6) differ from true ant-lions in having much larger heads and jaws; the body is thick, but more or less flattened above, and the lateral processes are well developed; they hide away under débris. Cocoon spherical, but disguised by having bits of débris, leaves, twigs, etc., spun into the silk. Most of the Australian species belong to *Suhpalacsa** and *Acmonotus*; in the latter genus the males have a raised, conical process dorsally on the second abdominal segment. *S. flavipes* Leach (pl. 24, fig. 10) and *S. subtrahens* Walk. are the commonest species in Eastern Australia; the black and orange *A. magnus* McL. ranges across to Western Australia, where also the much smaller, dark grey *A. incusifer* McL. is more rarely found. The family is absent from Tasmania and New Zealand.

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*An uncouth anagram from *Ascalaphus*; even the Greek "ph" is reversed to "hp" to suggest the antipodean character of the genus!

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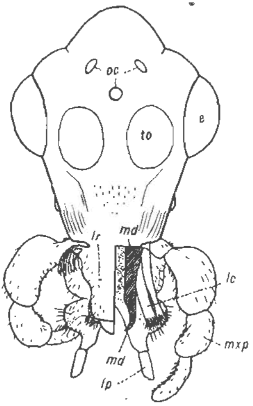
CHAPTER XXIV

Order MECOPTERA*

(Scorpion-flies)

THIS small but very interesting Order contains the peculiar insects known as Scorpion-flies, the name having been given owing to the curious formation of the abdomen of the males in the family Panorpidae, in which the bulbous *genitalia* of seg. 9 are carried curved forwards over the preceding segments, like the sting of a scorpion. Needless to say, the insects are quite harmless and do not possess a sting. Though only 170 species are known to exist in the World to-day, the Order is a very ancient one; the earliest Endopterygote fossils yet discovered (of Lower Permian age) are true Mecoptera allied to the existing Australian Choristidae. The members of the Order may be recognised by their long wings, with well rounded apices, the fore and hind wings being closely similar, with primitive, dichotomically branched venation, and by the lengthening of the front part of the head and the mouth-parts.



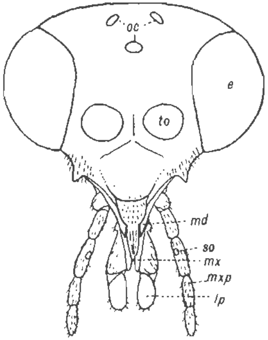


FIG. V1. Head of *Chorista australis* Klug, male, Australia. Fam. Choristidae.

FIG. V2. Head of *Nannochorista dipteroides* Till., male, Tasmania. Fam. Nannochoristidae.

Lettering for both figs.:—*e*, compound eye; *lc*, lacinia; *lp*, labial palp; *lr*, labrum (left half cut away to show mandible in V2); *md*, mandible; *mx*, maxilla; *mxp*, maxillary palp; *oc*, ocelli; *so*, sense-organ; *to*, torulus. [*A. Tonnoir del*

*The Neuroptera, Mecoptera, Diptera, Siphonaptera, Trichoptera and Lepidoptera are sometimes spoken of collectively as the Mecopteroid Orders or the Panorpoid Complex (p. 472). They are all undoubtedly very closely allied.

Characters. H e a d (figs. V1, 2) always more or less produced in front to form a kind of rostrum; *compound eyes* present, large, separated; three *ocelli* present; *antennae* filiform, arising fairly close together. *Mouth-parts* hypognathous, always more or less lengthened, showing the earlier stages of the evolution of the primitive mandibulate type into a piercing or sucking type; *labrum* medium to long; *mandibles* either slender and elongated, with sharp apices either simple or notched, or reduced to functionless, triangular plates; *maxillae* with long, usually 5-segmented palps, the basal segment usually very short, the third segment sometimes with a well-defined sense-organ; galea elongated and very slender, or entirely absent; lacinia well developed, often with strong brushes of hairs at its apex, and sometimes also divided into two separate lobes by a longitudinal split; *labium* with two-segmented palpi, either free or partially fused basally to form a primitive labellum; glossae and paraglossae absent or vestigial, (see figs. A3, V1, V2).

T h o r a x with small or medium *prothorax; meso-* and *metathorax* well-developed, subequal, with rather narrow, elongate episterna and epimera. *Legs* with elongate coxae, those of the middle and hind legs having a well marked meron; femora rather slender; tibiae slender with apical spurs; tarsi long, 5-segmented, the basal segment longest; the last segment ending in a pair of small claws. *Spiracles* two pairs.

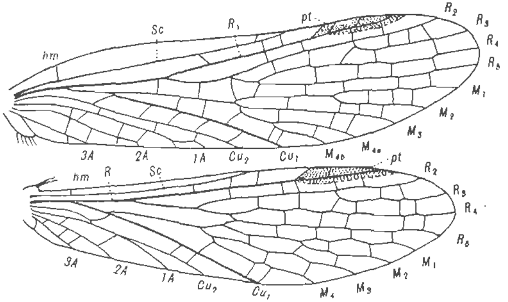


FIG V3. Wing-Venation of *Chorista australis* Klug, Australia. Fam. Choristidae. Lettering as in fig. A8, p. 22, except *fr*, frenular bristles; *pt*, pterostigma. [R. J. T *del.*]

W i n g s held roof-wise over the abdomen, either steeply or flatly; in shape elongate, with well-rounded apices. *Venation* of fore and hind wings closely similar, but hindwing has a narrower base and costal area, *Sc* shorter than in forewing, and *1A* partially fused with Cu_2. *Sc* and R_1 simple; a well-marked pterostigma generally present, frequently overlapping into the space between R_1 and R_2; *Rs* and *M* with five or four branches, dichotomically arranged, (rarely *Rs* has only three); Cu_1 a strong, convex vein without branches; Cu_2 unbranched, weak, concave; three anal veins usually present. Humeral veinlet (*hm*) and sometimes other costal veinlets present; cross-veins

irregularly placed, usually fairly numerous, sometimes very weakly chitinized; only in Nannochoristidae reduced to a small number, constant in position. Hindwing usually with one or two frenular bristles at base of costa.

A b d o m e n cylindrical or narrowly fusiform, with ten segments, the tenth being very small; cerci present, 1-3 segmented. Males (fig. V4) with complicated genitalia, the ninth segment highly specialized, with tergite and sternite fused together to form a narrow basal ring with their distal portions projecting from it, the sternite bifid, and enclosing

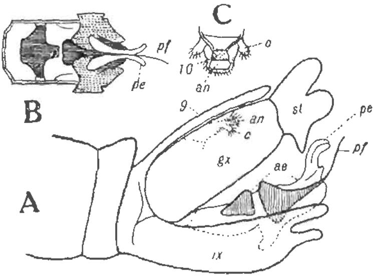


FIG. V4. A, end of abdomen of male of *Chorista australis* Klug; B, ventral view of aedeagus of same, dissected out, showing the supporting framework, chitinous plates, penis and penisfilum; C, dorsal view of reduced tenth segment, with cerci and anus; 9, 10, last two abdominal tergites; ix, ninth sternite; *an*, anus; *c*, cercus; *gx*, gonocoxite; *pe*, penis; *pf*, penisfilum; *st*, style (clasper). [*R. J. T. del.*

the more or less greatly enlarged *gonocoxites* (*gx*) which form the swollen bulb at the end of the abdomen in most forms; these gonocoxites usually carry *styles* (*st*) developed as claspers for pairing; above the bifid sternite is the *aedeagus* (*ae*), consisting of a bilobed *penis* (*pe*) sometimes with a long terminal thread (*penisfilum, pf*); situated dorsally between the upper portions of the bases of the gonocoxites, and below the ninth tergite, is the small tenth segment or *proctiger*

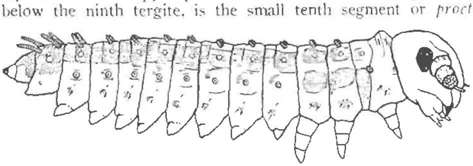


FIG. V5. Larva of *Chorista australis* Klug. First instar. Length 3 mm [*R. J. T. del.*

(fig. V4, C) carrying the unsegmented *cerci* (*c*). Females (fig. V6) with the end segments narrow and elongated, forming a tubular ovipositor; eighth sternite produced posteriorly into a subgenital plate; ninth and tenth segments reduced, the latter carrying a pair of short, seg-

mented or simple cerci. *Spiracles* usually eight pairs, on segs. 1-8; sometimes reduced to 7 or 6 pairs. *Malpighian tubules* six.

Life History. The early stages are terrestrial, except in the Nannochoristidae, which are almost certainly either wholly or partially aquatic. The *eggs* are broadly oval, soft and smooth (Choristidae) or cubical, hard, and with somewhat concave faces (Bittacidae); the former are laid in clumps in suitable moist hollows in the soil, the latter appear to be dropped freely. The *larva* (Choristidae, fig. V5) is eruciform, with short thoracic legs and with very short, segmented, abdominal legs on segs. 1-8; these latter are well developed in the first instar, when they are used for walking, but later on degenerate. The larva is remarkable in having a pair of compound eyes with numerous hexagonal facets; the antennae are 3-segmented, the second segment being swollen into a kind of dome and carrying a large Johnston's organ. A pair of annulated processes projects from the dorsal region of each segment from the mesothorax to the ninth abdominal, the last-named segment having two pairs, longer than the others; the chaetotaxy is comparable with that of the larvae of Lepidoptera and of the Ithonidae. The *pupa* (fig. V6) is a very soft, delicate, quiescent *pupa libera*, lying free in moist earth or in an earthen cell; it is peculiar in having the last three or four segments of the abdomen bent backwards in both sexes; cerci are present. The number of larval instars is from four to six; the exuviae, both of larva and pupa, are exceedingly delicate and shrivel up after ecdysis. The imagines are diurnal insects, mostly inhabiting damp, cool places where the dew lingers long; the Nannochoristidae are only found along the borders of streams, lakes and mountain bogs. Most of the species are quick at taking flight, but fly slowly and heavily; the little Nannochoristidae, however, are very active fliers. They are not attracted to light, but visit foliage and blossoms freely, especially tea-tree (*Leptospermum*); the Bittacidae are predaceous, killing and carrying off numerous small insects.

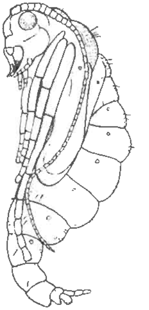


FIG. V6. Pupa of *Chorista australis* Klug, female. Length 12 mm. [*R. J. T. del.*

Distribution. Three families are found in our region, one of which, the Choristidae, is confined to Australia, while another, the Nannochoristidae, is only found there and in New Zealand; the third family, Bittacidae, is world-wide. Of the families not represented in our fauna, the Panorpidae and the wingless Boreidae are found in the Northern Hemisphere, while the Meropidae (*Merope* and *Notiothauma*) are confined to the New World.

Fossil History. Small, undescribed species of Mecoptera allied to the Choristidae occur in the Lower Permian of Kansas, and are the oldest recognizable Holometabolous insects yet discovered. In the Upper Permian of Belmont, New South Wales, the Mesochoristidae were one of the dominant types; they only differed from true Choristidae by their somewhat smaller size and in having a six-branched media. The same group reappears in the Upper Trias of Ipswich, Queensland. The Choristidae, and perhaps also the Nannochoristidae,

are the direct descendants of these forms. The Bittacidae are a later group, not found as fossils in Australia. Extinct Orders closely allied to the Mecoptera occur in the Upper Permian (Paramecoptera) and Upper Trias (Paratrichoptera); a fuller account of these is given on pp. 472, 476.

Economics. The Order is entirely beneficial but of little actual value. The larvae feed on vegetable débris or insect remains; the rapacious Bittacidae capture flies and other insects on the wing.

CLASSIFICATION

SCHEME OR CLASSIFICATION AND CENSUS OF SPECIES

Order MECOPTERA 12 (1)

Suborder PROTOMECOPTERA	(MEROPIDAE)
Suborder EUMECOPTERA 12 (1)	1. CHORISTIDAE 4 (0) (PANORPIDAE) 2. NANNOCHORISTIDAE 4 (1) (BOREIDAE) 3. BITTACIDAE 4 (0)

The Order may be divided into two very distinct Suborders as follows:—

Both *Rs* and *M* with more than four branches; male genitalia of simple type, with slender gonocoxites and styles.
Suborder PROTOMECOPTERA

Either *Rs* or *M*, or both, with only four branches or less; male genitalia of more complex type, with enlarged gonocoxites.
Suborder EUMECOPTERA

The Protomecoptera contains only one recent family, the Meropidae, together with the Upper Triassic fossil family Archipanorpidae. The Eumecoptera include the three families found in our region, together with the Panorpidae and Boreidae; these may be separated as follows:—

1. Legs raptorial, tarsi ending in a single claw. Fam. 3. BITTACIDAE
   Legs normal, tarsi ending in two claws. 2
2. Small, dark species, with vestigial wings. [Fam. BOREIDAE]
   Species with all four wings present. 3
3. Small, active species with *Rs* 3-branched and with few cross-veins, arranged in fixed positions. Fam. 2. NANNOCHORISTIDAE
   Larger species with *Rs* having four or more branches, and with more numerous cross-veins irregularly placed (sometimes very feebly chitinized). 4
4. *M* with four branches in both wings; *Rs* usually with more than four. [Fam. PANORPIDAE]
   M with five branches in forewing, four in hind; *Rs* always with four branches. Fam. 1. CHORISTIDAE

Family 1. **Choristidae** [Aus. 4, N.Z. 0]. Head with short rostrum; antennae as long as, or longer than forewings; labrum broad; mandibles strong, pointed, without teeth; maxillae with divided lacinia, hairy at apex, galea absent; maxillary and labial palpi of males highly specialized. Wings carried in a high, roof-like manner over the body; forewing with *M* 5-branched, the extra branch being on M_4; abdomen of male short, the genitalia bulbous, but not carried over the back as in Panorpidae.

There are only two known genera, each with two species. *Chorista* has dark venation on a yellowish wing-membrane and no veinlets except *hm* in costal space; the best-known species, *Ch. australis* Klug (fig. V3 and pl. 26, figs. 1, 2) is a rare insect only found in damp, shady places in April. The larva (fig. V5) is semi-transparent pinkish in colour, and lives in short tunnels in soft soil or under débris; it comes out at night and feeds on vegetable débris, moss, lichens, etc.; its spiracles (fig. A14) are of very striking design, with a rosette of twenty or more openings placed on a circular disc. The pupa lies free in the burrow, two or three inches down in the soil. The allied genus *Taeniochorista* differs only in having pale venation with weakly formed cross-veins, and with several extra costal veinlets in addition to *hm*; *T. pallida* E. P. occurs rarely round Brisbane. A peculiar habit of these insects is that, during pairing, the male embraces the mouth of the female in its swollen palps and exudes from them a sweet, sticky secretion with which he feeds her.

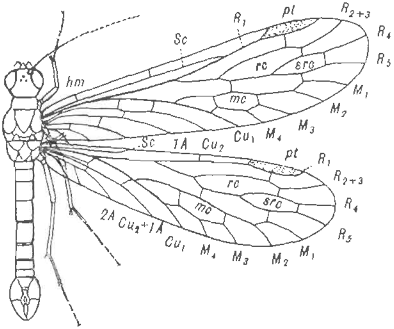


FIG V7. *Nannochorista dipteroides* Till., male, Tasmania. Fam. Nannochoristidae. Length of body 6 mm. Lettering as in fig. A8, p. 22; except *mc*, median cell; *pt*, pterostigma; *rc*, radial cell; *src*, subradial cell. [*R. J. T. del.*

Family 2. **Nannochoristidae** [Aus. 4, N.Z. 1]. Head a globular capsule resembling that of the Diptera, with short rostrum; antennae about half as long as forewings; labrum short, pointed; mandibles reduced to non-functional, triangular plates; maxillae with a slender internal lobe (probably the lacinia) and 5-segmented palpi with a sense-organ on seg. 3; labium with two-segmented palpi partially fused at bases, and somewhat resembling a primitive Dipterous labellum. Wings held nearly vertically over body (as in small lacewings); *Rs* with 3 branches and closed radial (*rc*) and subradial (*src*) cells; *M* with 4 branches and closed median cell (*mc*); abdomen of male much as in Choristidae.

Four species of *Nannochorista* (fig. V7) are known from Australia, three of which are confined to Tasmania; the allied genus *Choristella* is found in New Zealand. All the species are small, expanding up to 15 mm. at most, and are only found along the banks of streams, lakes and mountain bogs; they are active in flight and capable of springing into the air from rest. The larvae (unknown) are almost certainly aquatic.

Family 3. **Bittacidae** [Aus. 4, N.Z. 0]. Head with an elongate rostrum and mouth-parts; antennae very slender, less than half as long as forewings; labrum and mandibles long and slender, the latter notched at tips; maxillae with large, split lacinia carrying strong brushes of hairs distally, and with a smaller and much slenderer galea; maxillary palpi 5-segmented, the basal segment very short; labium with slender, 2-segmented palpi of normal form. Legs raptorial, long and slender, the tibiae with long spurs, the tarsi ending in a single claw only; in the hind legs, the tibiae and tarsi are thicker, and the latter can be curled round a captured insect, holding it in a strong grasp; at the same time,

the hind legs can be brought forward to act as a pair of arms, bringing the prey within reach of the mouth, while the fore and middle legs are used to cling to convenient twigs. Wings very narrow, with more or less petiolate bases; *3A* vestigial; *Rs* and *M* 4-branched.* Abdomen long, cylindrical, the male genitalia short, not bulbous, the styles small or absent.

The genus *Harpobittacus* contains three fine species expanding up to 2 inches or more; they are not uncommon in open country in Australia in the spring, and often visit tea-tree (*Leptospermum*), capturing flies and other insects from the blossoms. *H. tillyardi* E. P. (pl. 26, fig. 3) occurs round Sydney; the allied *H. australis* Klug is found in Tasmania and Victoria. A single species of *Bittacus* is recorded from Queensland. The life-history of these insects is unknown, except that they lay peculiar, hard, cubical eggs with concave faces, which they appear to drop freely on the ground.

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*The Californian genus *Apterobittacus* is entirely wingless.

CHAPTER XXV

Order DIPTERA

(Two-winged Flies)

THIS very extensive Order includes such well-known insects as the Crane-flies, Gnats, Mosquitoes, Sand-flies, March-flies, Robber-flies, Blow-flies and the ubiquitous House-fly. With the exception of certain entirely wingless forms, whose affinities can only be determined by their life history and comparative morphology, the members of the Order are all recognized at once by possessing only a single pair of wings, viz., the forewings, while the hindwings are reduced to a pair of small, club-like appendages called *halteres*, balancers, or poisers.

Characters. Small to moderate, seldom very large insects, having the integument generally fairly soft, often very hairy or bristly.

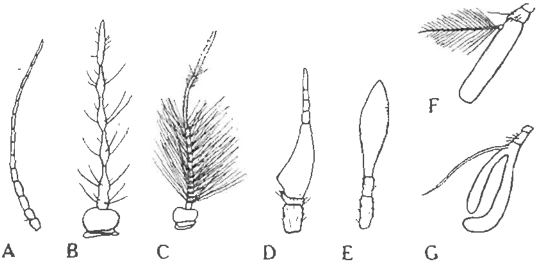


FIG. W1. Examples of antennae of Diptera; A, *Edwardsina tasmaniensis* Tonn., fam. Blepharoceridae, Australia; B, *Chironomus zealandicus* Huds., female, fam. Chironomidae, New Zealand; C, *Culex pervigilans* Berg., male, fam. Culicidae, New Zealand; D, *Tabanus circumdatus* Walk., fam. Tabanidae, Australia; E, *Laphria rufifemorata* Macq., fam. Asilidae, Australia; F, *Anastellorhina stygia* Fabr., fam. Muscidae, Australia and New Zealand; G, *Schizotachina fergusoni* Bez., fam. Tachinidae, Australia. [*A. Tonnoir del.*

Head generally in the form of a rather small, more or less spherical capsule, a considerable area of which is occupied by the large *compound eyes*; these may be separated from one another (dichoptic) or meeting in the mid-dorsal line (holoptic); the area between and behind the eyes is the epicranium, the posterior portion being called the occiput, the upper portion as far as the ocelli the vertex, and the anterior

portion from ocelli to antennae the frons; three *ocelli* are usually present, (absent in Tipuloidea, Culicoidea, Simuliidae, Cecidomyiidae and some Mycetophilidae), and placed close together in a triangle. *Antennae* inserted usually well forward on the frons, and composed of a scape, pedicel* and a variable number of more or less similar segments (distalia) forming the flagellum. The primitive number of segments in the antenna appears to have been sixteen, but larger numbers up to as much as 39 occur in some Nematocera genera. In all the higher groups the number is greatly reduced, to six or less. In the highest forms of all (Cyclorrhapha), there appear to be only three segments, viz., scape, pedicel and a large third segment; but a delicate, bristle-like appendage, arising either from near the base or apex of the third segment, and called the *arista* (fig. W1, *f, g*), really represents the rest of the flagellum greatly modified; it is sometimes composed of two or three segments. The part of the head below the antennae as far as the mouth is known as the face; it consists of a distinct median plate, the *clypeus*, and two lateral extensions of the epicranium bordering the eyes; these are the cheeks or *genae*. In the highest group (Cyclorrhapha Muscoidea) there is, just above the antennae, a sickle-shaped infolding of the cuticle called the *frontal lunule* (fig. W11, *frl*) within which is the membranous, bladder-like *ptilinum*, an organ used by the fly in emerging from the puparium. *Mouth-parts*:—These always project more or less below the head capsule (hypognathous type) and are of a piercing or sucking type,

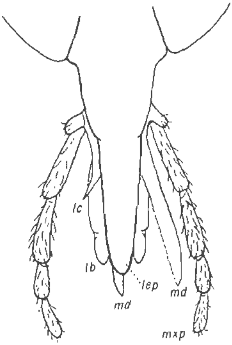


Fig. W2. Mouth-parts of *Edwardsina tasmaniensis* Tonn., female. Fam. Blepharoceridae. Right lacinia and left mandible displaced. [*A. Tonnoir del*

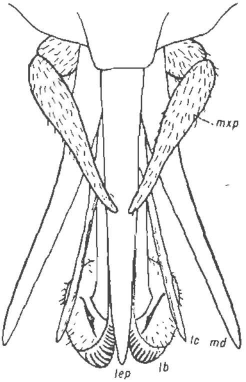


Fig. W3. Mouth-parts of *Tabanus circumdatus* Walk., female. Fam. Tabanidae. [*A. Tonnoir del.*

never normally mandibulate. The *labrum* is always narrow, sometimes very elongated; it combines with the epipharynx beneath to form a single organ, the *labrum-epipharynx*, often used as part of the piercing

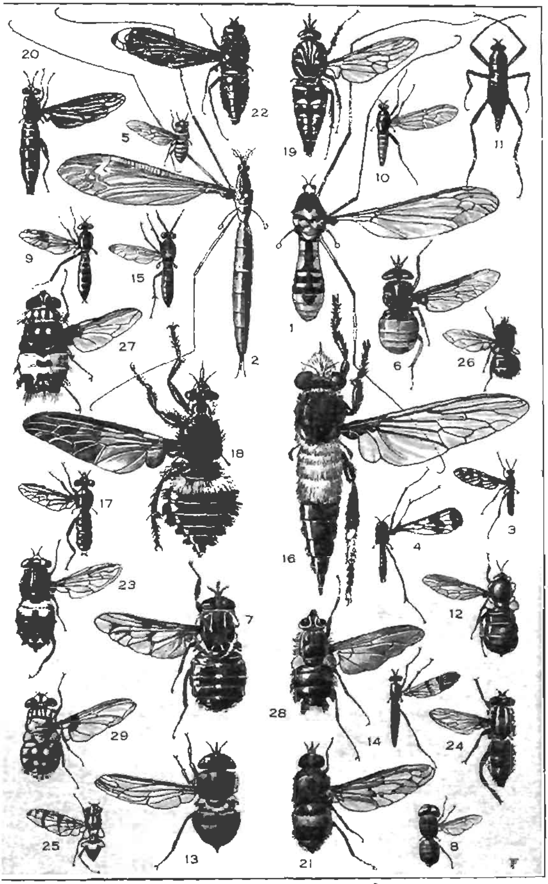
*Most Dipterists use the term "scape" for the two basal segments together.

PLATE 25

DIPTERA

All figures natural size except figs. 3 and 5

1. *Semnotes imperatoria* Wwd. (Fam. TIPULIDAE), female.
2. *Longurio dux* Huds. (Fam. TIPULIDAE), female, N.Z.
3. *Rhyphus neozelandicus* Sch. (Fam. RHYPHIDAE), (x 1.3), Aus and N.Z.
4. *Nervijuncta hudsoni* Hutt. (Fam. MYCETOPHILIDAE), male, N.Z.
5. *Spaniopsis longicornis* Ferg. (Fam. LEPTIDAE), (x 1.3).
6. *Osca subappendiculata* Macq. (Fam. TABANIDAE).
7. *Erephopsis guttata* Don. (Fam. TABANIDAE).
8. *Odontomyia decipiens* Guer. (Fam. STRATIOMYIIDAE).
9. *Neoexaireta spinigera* Wied. (Fam. STRATIOMYIIDAE).
10. *Boreoides subulatus* Hardy (Fam. STRATIOMYIIDAE), male.
11. *Boreoides subulatus* Hardy (Fam. STRATIOMYIIDAE), female.
12. *Panops baudini* Lam. (Fam. CYRTIDAE).
13. *Trichophthalmus nigripes* Macq. (Fam. NEMESTRINIDAE).
14. *Ectinorrhynchus viduus* Sch. (Fam. THEREVIDAE), female.
15. *Agapophytus albopunctatus* Roder (Fam. THEREVIDAE).
16. *Phellus glaucus* Walk. (Fam. ASILIDAE), female.
17. *Laphria clavata* Wh. (Fam. ASILIDAE).
18. *Blepharotes splendidissimus* Wied. (Fam. ASILIDAE).
19. *Apiocera asilica* Wwd. (Fam. APIOCERIDAE).
20. *Miltinus viduatus* Wwd. (Fam. MYDAIDAE).
21. *Hyperalonia bombyliformis* W.S.M. (Fam. BOMBYLIIDAE).
22. *Comptosia fascipennis* Macq. (Fam. BOMBYLIIDAE).
23. *Pilinasica cingulata* Fabr. (Fam. SYRPHIDAE).
24. *Milesia bilineata* Walk. (Fam. SYRPHIDAE).
25. *Euprosopia tenuicornis* Macq. (Fam. ORTALIDAE).
26. *Anastellorhina stygia* Fabr. (Fam. MUSCIDAE).
27. *Euamphibolia fulvipes* Guer. (Fam. TACHINIDAE).
28. *Chaetogaster violacea* Macq. (Fam. TACHINIDAE).
29. *Amoenia leonina* Don. (Fam. TACHINIDAE).



P. Tillyard del.

DIPTERA

apparatus; the epipharynx itself has two distinct side-pieces, the *tormae*. The *mandibles* are never of a biting type, but are either entirely absent, or developed as spears for piercing; their distal edges may be finely serrated. The *maxillae* have the cardo and stipes reduced, fused with the head-capsule; the palp is well-developed in the older forms, with

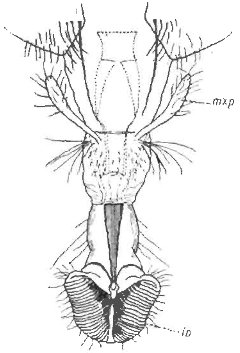


FIG. W4. Mouth-parts of *Anastellorhina stygia* Fabr. Fam. Muscidae; *lb.* labellum; *mxp.* maxillary palp.
(*A. Tonnoir del.*

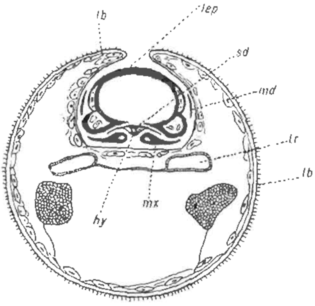


FIG W5. Transverse Section through mouth-parts of a Mosquito. (x 830). Fam. Culicidae, (after Patton and Cragg); *hy.* hypopharynx; *lb.* labium; *lep.* labrum-epipharynx; *md.* mandible; *mx.* maxilla; *sd.* salivary duct; *tr.* trachea.

4-5 segments, but is reduced to a single segment in the higher forms; the lacinia is present as a slender rod in some of the older groups only, absent in the rest; the galea is always absent. The *labium* is very highly specialized and characteristic of the Order; both mentum and submentum are reduced to membranous areas on the underside of the head; beyond them there projects a chitinous piece called the *theca*, whose homologies are doubtful; beyond this, again, is a terminal, more or less swollen, bulbous portion, formed of two lobes or *labella*; in some of the older forms the two labella are widely separated, and between them are to be seen either one or two small processes, the vestiges of the internal lobes. Many Dipterists hold that the labella are formed from the paraglossae, the small parts found between them are the glossae, and the palpi are absent; but there is no real evidence for this view, and a comparison with the labium of the Mecoptera (fig. V1, 2), which approaches that of the Diptera most closely, seems to indicate the strong probability that the labella are formed from partially fused palpal segments; the theca, which shows in some archaic types distinct evidence of a division into two parts, may very well be the fused basal segments of the palpi, the labella the partially fused distal segments. The *hypopharynx* is well developed, standing out as a narrow, more or less elongated, tongue-like process above the labium; in many types it is very similar to the labrum-epipharynx in appearance. The *salivary apparatus* is always well

developed, and the duct is generally carried forward in a groove to the end of the hypopharynx.

A peculiarity of the labella is the development on their surface of chitinized troughs called *pseudotracheae* (fig. W4). In the higher forms, they are extensively branched, and are supported, in cross-section, by numerous minute U-shaped rings of hard chitin, which give them their superficial resemblance to true tracheae. They appear to act as a filter in the process of licking or sucking, preventing large particles from being swallowed.

In order to understand the mechanism of the mouth-parts of a Dipteron, a transverse section of the mouth of a mosquito is given in fig. W5. It will be seen that the mouth-parts enclose two separate passages, the upper one conveying the liquid food into the mouth, by the sucking action of the pharynx, and the lower one projecting saliva into the wound from the salivary glands at the same time.

The term *proboscis* is a general one, and indicates the whole of the piercing and sucking apparatus of the mouth; its use should be avoided in detailed descriptions.

T h o r a x :—The three parts of the thorax are more diverse in size in the Diptera than in any other Order. The *prothorax* is always very small, forming a neck or collar, with a small propleural plate and a small prosternum carrying the fore coxae. The *mesothorax* is very large, embracing practically all the visible dorsal and lateral parts of the thorax; the *mesonotum* is very large, convex, sometimes with a V-shaped suture; it has a posterior portion, the *scutellum*, separated off by a definite groove; this projects backwards as a sub-triangular lobe, and usually hides the *postscutellum** from view. The mesopleuron is divided up into three distinct portions, called by Dipterists the *meso-*, *sterno-*, and *pteropleuron* respectively (fig. W12); the first two are actually the two parts of the mesepisternum, the third is the mesepimeron. The mesothoracic or first thoracic spiracle lies well forward, between the mesepisternum and the prothorax. The *metathorax* is much reduced in size, the only part at all clearly marked being the so-called *hypopleuron*, which is a part of the metapleuron proper; the piece above this, commonly called by Dipterists the *metapleuron*, is in reality a side-piece of the large mesonotum. The metathoracic spiracle is to be found just above the hypopleuron.

The halteres in the higher forms are covered over by two scale-like processes; the lower of these is called the *squame*, and is immobile; the upper is the *antisquame*, and moves with the wing.

The *legs* are all usually of similar form, the hind pair being the longest. A few forms have raptorial forelegs; others have the hind femora much swollen. In a few archaic forms, we find the coxa elongated, and, in the case of the middle leg only, divided into two distinct parts (true coxa and meron) as in Mecoptera; but in the higher forms the coxa becomes short and undivided. The trochanter is small, the femur long and fairly stout, the tibia usually long and slender. The tarsus consists of five distinct segments, and ends in two strong claws. Between the claws there may be developed a single median appendage (*empodium*), either in the form of a pad, spine or bristle; or there may be a pair of processes from the last segment, extending in the form of a bilobed pad under the claws (*pulvilli*); in some forms,

*This sclerite is commonly called the "metanotum" by Dipterists.

both empodium and puvilli are present, in others, both are absent, figs. W6, 7).

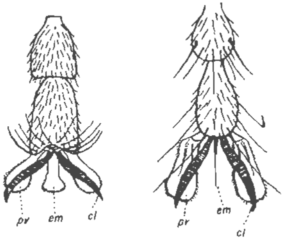


FIG. W6. End of tarsus of Brachycera, Tabanoid type: *Tabanus circumdatus* Walk. Fam. Tabanidae.
FIG. W7. End of tarsus of Brachycera, Asiloid type: *Neoitamus vulgatus* White. Fam. Asilidae. *cl*, claw; *em*, empodium; *pv*, pulvillus. [*A. Tonnoir del.*

Wings:—The *wings* (forewings) have a narrow base and strong costal margin, thickened up to the apex or beyond it; in some forms the thickening extends completely round the wing. Fig. W8 shows diagrammatically the *original* scheme of venation for the Order. It should be noticed that *Rs* was originally four-branched. But all four branches are only now to be found in the Tanyderidae and some Psychodidae; most forms have three or less. A closed *radial cell* (*rc*) was originally present, but is now only to be found in *Tanyderus* (fig. W21); it is closed distally by the *inter-radial cross-vein* (*ir*). A *radio-median cross-vein* (*r-m*) usually connects R_{4+5} with M_{1+2}. *M* is normally four-branched and includes the *median cell* (*mc*), which is closed distally by the *inter-median cross-vein* (*im*.) In many of the higher forms, the number of branches of *M* is reduced, or they may fuse in various ways; also the median cell may be absent. Below *M* runs the oblique, strong,

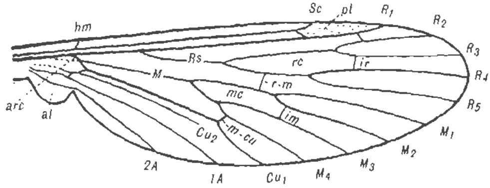


FIG. W8. Diagram of complete archaic venational scheme for the Order Diptera (cf. Trichoptera, fig. Y1, in which Cu_1 is forked). Lettering as in fig. A8, p. 22; except *al*, alula; *arc*, arculus; *im*, inter-median cross-vein; *ir*, inter-radial cross-vein; *mc*, median cell; *m-cu*, medio-cubital cross-vein; *pt*, pterostigma; *r-m*, radio-median cross-vein; *rc*, radial cell. [*R. J. T. del.*

convex vein Cu_1; as in the Mecoptera, this vein has no branches, but it is connected with *M* above by the *medio-cubital cross-vein* (*m-cu*) and is often bent at this point. In many forms, this cross-vein becomes oblique or longitudinal, and the basal piece of M_4 transverse, so that it would appear at first sight as if M_4 were an upper branch of Cu_1; the basal piece of M_4 may even become suppressed, when the rest of it will appear completely attached to Cu_1 (see Blepharoceridae, figs. W37, 38).

Cu_2 is weak, very close below Cu_1, and only present in some archaic forms; it never reaches the wing-margin. There are never more than two anal veins; *1A* is strong, convex, and either parallel to Cu_1 or converging towards it and even fusing with it distally. *2A* is short, vestigial or entirely absent. Near the base, *R* gives off in many forms a strong oblique vein called the *arculus* (*arc*), which connects basally with *M*; it is doubtful whether it is the true basal portion of *M* or not. At the base of the posterior margin there is a definite lobe, the *alula* (*al*), marked off by a more or less deep constriction from the rest of the same margin.*

The older Dipterists studied the venation without reference to that of other Orders, and evolved their own system of nomenclature, which is still in use by many workers. We give below, for the help of students, a Table in which the amended Comstock-Needham Notation is compared with two older notations, generally known as Loew's and Schiner's respectively:—

COMPARATIVE TABLE OF VENATIONAL SYSTEMS IN DIPTERA

Comstock-Needham System (amended)		Loew.	Schiner.
Name.	Notation.		
Costa	*C*	Costa	Costa
Subcosta	*Sc*	Mediastinal	Auxiliary
Radius:—	*R*		
Main Stem	R_1	Subcostal (or Marginal)	First Longitudinal
Radial Sector:—	*Rs*	—	—
First Branch	R_2	Radial (or Submarginal)	Second Longitudinal
Second Branch	R_3		
Third Branch	R_4	Cubital, upper branch	Third Longitudinal
Fourth Branch	R_5	Cubital, lower branch	
Media:—	*M*		
First Branch	M_1	First postical† (or posterior)	Fourth Longitudinal
Second Branch	M_2	Second postical (or posterior)	
Third Branch	M_3	Third postical (or posterior)	Fifth Longitudinal (distal part)
Fourth Branch	M_4	Fourth postical (or posterior)	
Cubitus:—			
First Branch	Cu_1	Fifth postical (or posterior)	Fifth Longitudinal (basal part)
Second Branch	Cu_2	—	—
First Anal	*1A*	Anal	Sixth Longitudinal
Second Anal	*2A*	Axillary	Axillary

*It should be noted that the above description of the venation is not accepted by all Dipterists, the parts in dispute being the limits of *M* and *Cu*. Comstock holds that M_4 does not exist in Diptera, and calls the vein here labelled M_4, Cu_1; the distal part of Cu_1 he calls Cu_2, and ignores the weak vein here labelled Cu_2. That this is incorrect can easily be proved from Comstock's own figures of Perlaria and *Sialis*. Other Dipterists, with more reason, would call these two veins Cu_{1a} and Cu_{1b} respectively; they are, however, equally unable to account for M_4, and have not considered the weight of evidence from fossils and from a comparison with the wings of the very closely allied Mecoptera, both of which show clearly that the media is four-branched and Cu_1 simple. The strength of their view lies in the fact that so many Diptera have M_4 appearing as a branch of Cu_1: as long as this is regarded as a primitive character, no other view is possible; but a study of how this has been brought about in the Blepharoceridae should convince them (see figs. W37, 38).

†Or, alternatively, M_{1+2} was called the discoidal or discal vein, M_{3+4} the postical vein. These systems also gave names to the separate closed spaces or cells of the wing, the closed median cell being called the *discoidal cell* and that between *Cu*, and *1A* the *anal cell*. The others need not be given in detail here, but can be referred to in Williston or Verrall (Stratiomyiidae, etc., of Great Britain).

The *halter* (vestigial hindwing) is a small organ having a slender stem or *petiole* (sometimes called the *pedicel*, but this term is already in use for the second antennal segment) and a swollen terminal club or *capitellum*; the slightly swollen base of the petiole, known as the *scabellum*, articulates with the side of the reduced metanotum, i.e. above the hypopleuron and posteriorly to the so-called metapleuron. The halteres can be vibrated rapidly and are generally supposed to assist the insect in maintaining its balance during flight.

A b d o m e n of variable shape, usually subcylindrical or somewhat flattened or swollen. There are nine complete segments, and vestiges of a tenth, but it is seldom that all nine are visible without special preparation. Usually seven pairs of *spiracles* are present, on segs. 1-7 respectively; the eighth pair is only present in some of the older forms, and in some of the highest forms there may be only six, or even only five pairs altogether. The male has the ninth segment much modified in connection with the specialized copulatory apparatus; it is spoken of as the *hypopygium*; in certain families (Culicidae, Psychodidae, Rhyphidae and a few Tipulidae) the hypopygium undergoes a complete twist through 180°, so that the tergite and sternite change places.

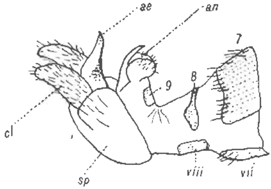


FIG W9. Normally placed end-segments of abdomen in male of *Edwardsina confinis* Tonn., fam Blepharoceridae. Lateral view. Lettering as in fig. W10. [*A. Tonnoir del*

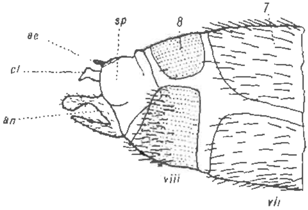


FIG. W10. Abnormally placed end-segments of abdomen in male of *Rhyphus notatus* Hutt., fam. Rhyphidae. Lateral view; *ae*, aedeagus; *an*, anus; *cl*, clasper; *sp*, side-piece; *7, 8, 9*, abdominal tergites; *vii, viii*, abdominal sternites. [*A. Tonnoir del.*

The ninth sternite carries a pair of gonapophyses (lateral gonapophyses, see p. 26), each having a large basal coxite called the *side-piece*, and a movable distal segment (style), called the *clasper**. The anus is borne

*Some authors call the side-pieces the "accessory plates" and the claspers the "forceps".

on a small papilla (tenth segment), and between this and the ninth sternite is found the *aedeagus*, consisting of the penis, its sheath and accessory structures. In the female, the end segments are generally more or less telescopic, as in Mecoptera; the primitive ovipositor is only represented by a pair of valves (gonocoxites) on seg. 9, generally greatly reduced; seg. 10 is short, so that the gonopore is situated close to the end of the abdomen, but actually on seg. 9. *Cerci* absent. *Malpighian tubules*, four in number, rarely five.

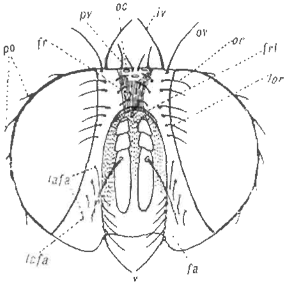


FIG. W11. Chaetotaxy of head, diagrammatic, front view; *fa*, facials; *fr*, frontals; *frl*, frontal lunule; *iv*, inner verticals; *lafa*, lateral facials; *lor*, lower fronto-orbitals; *oc*, ocellars; *or*, fronto-orbitals; *ov*, outer verticals; *po*, postoculars; *pv*, postverticals; *v*, oral vibrissae. [*A. Tonnoir del.*

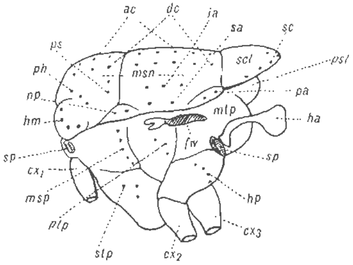


FIG. W12. Sclerites and chaetotaxy of thorax, diagrammatic, lateral view; *ac*, acrostichals; *cx*, coxa; *dc*, dorsocentrals; *fw*, forewing (cut off); *ha*, halter; *hp*, hypopleuron and hypopleural bristles; *hm*, humerals; *ia*, inter-alars; *msn*, mesonotum; *msp*, mesopleuron and mesopleural bristles; *mtp*, the so-called metapleuron (lower posterior part of mesonotum); *np*, notopleurals; *pa*, postalars; *ph*, posthumerals; *ps*, praesuturals; *psl*, postscutellum; *ptp*, pteropleuron and pteropleural bristles; *sa*, supra-alars; *sc*, scutellars; *scl*, scutellum; *sp*, spiracle; *stp*, sternopleuron and sternopleural bristles. [*A. Tonnoir del.*

Chaetotaxy :—The arrangement of the *bristles* or stiff hairs on the head, thorax and abdomen of certain Diptera is of great import-

ance in classification, and must be mastered by those who would obtain a good working knowledge of the Cyclorrhapha and some of the families of Brachycera. Figs. W11, 12 show diagrammatically the positions in which bristles may occur, with their "positional" names; most of these are not needed in distinguishing families, but the following are used in the Keys given below:—On the head:—*oral vibrissae* (*v*), *post-vertical bristles* (*pv*), *fronto-orbital bristles* (*or, lor*). On the thorax:—*hypopleural bristles*, (*hp*).

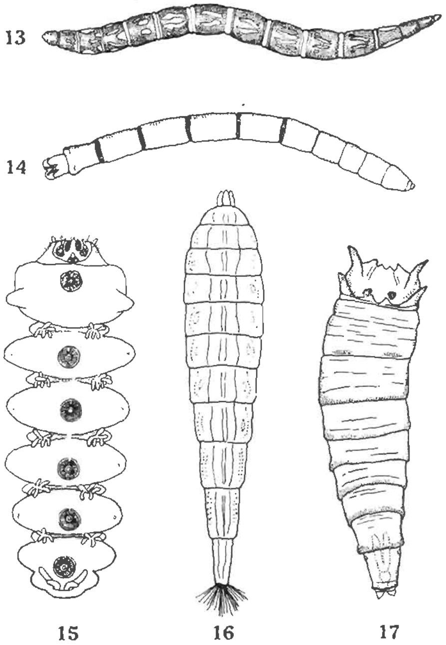
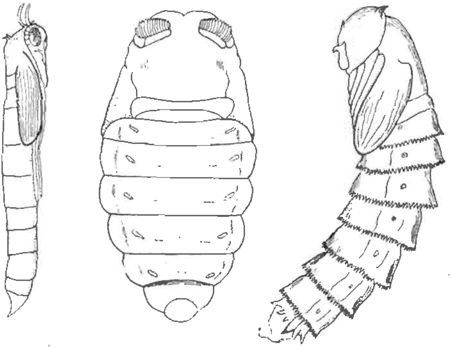


FIG. W13. Larva of ***Rhyphus notatus*** Hutt. Fam. Rhyphidae.
FIG. W14. Larva of ***Molophilus pulcherrimus*** Edw. Fam. Tipulidae.
FIG. W15. Larva of ***Edwardsina australasiensis*** Till. Fam. Blepharoceridae.
FIG. W16. Larva of ***Odontomyia decipiens*** Guer. Fam. Stratiomyiidae.
FIG. W17. Larva of ***Anastellorhina stygia*** Fabr. Fam. Muscidae.
[*A. Tonnoir del.*

Life History. The *eggs* of Diptera (fig. A18, B) are nearly always elongate oval in shape, usually soft, creamy or whitish in colour, but some (Tipulidae) lay hard, seed-like eggs, which are scattered about on the soil. They are laid either on leaves, in the ground, on or in water (sometimes in a gelatinous mass), on carcases and decaying matter,

etc. In some of the higher forms, the egg hatches inside the body of the female, and is laid as a young maggot (some Muscoidea) or full-fed and about to pupate (Hippoboscoidea and Tsetse-flies). Some species (e.g. Blowflies) may be either oviparous or viviparous.

The *larva* may be one of several very diverse forms, but all these agree in never having any true thoracic legs; a few forms have short, stumpy, abdominal prolegs, and others have abdominal processes in rows round the body. The larvae are roughly classified according to the degree of development of the head and the number of spiracles. The most archaic forms have a complete head-capsule (*eucephalic*), as in most of the Nematocera; a few (*Tipulidae*) have only the anterior portion of the head well-developed, and the head can be completely withdrawn into the prothorax (*hemicephalic*); the Cecidomyiidae, all the Brachycera except the Stratiomyiidae, and all the Cyclorrhapha, have the head greatly reduced, usually with only hook-like jaws present, and capable of great retraction into the thorax (*acephalic*). The acephalic larva is a true *maggot*, having the anterior end tapering. The aquatic groups of the Nematocera have many remarkable forms of eucephalic larvae. As regards the *spiracles*, the most primitive larval forms have two pairs on the thorax and eight on the abdomen; this type, and those in which the total of ten pairs is reduced to nine or eight, are called *peripneustic*; such primitive conditions obtain only in certain groups of Nematocera. If all but the prothoracic and last abdominal pairs are lacking, the larva is called *amphipneustic*; if the prothoracic pair only are present, *propneustic*; if the last abdominal pair only, *metapneustic*; if there are no spiracles, (as in Corethrinae) *apneustic*.



Figs. W18-20, from left to right:—
FIG. W18. Pupa of *Molophilus pulcherrimus* Edw. Fam. Tipulidae.
FIG. W19. Pupa of *Edwardsina tillyardi* Tonn., ventral view. Fam. Blephároceridae.
FIG. W20. Pupa of *Tabanid*, gen. et. sp. indet., Australia. [*A. Tonnoir del.*

The *pupa* is either a *pupa incompleta*, as in most of the older groups, or else the larva pupates within the pupal skin (Cyclorrhapha and Stratiomyiidae). The pupa incompleta is generally rather like the more

primitive type of Lepidopterous pupa as found in Hepialidae, and is often strongly armed with spines or hooks; those forms which live in damp earth or in water have breathing horns projecting from the pronotum, while some of the aquatic forms can also swim freely by flexing the abdomen. In the Stratiomyiidae the insect contracts within the old larval skin at metamorphosis, and a delicate *pupa libera* is formed inside that skin, which keeps its original shape and size. In the Cyclorrhapha, on the other hand, the skin of the maggot becomes hardened, usually into an oval, barrel-like *puparium*, and the tissues of the insect undergo a very complex breaking-up (histolysis), the fly itself being entirely rebuilt from certain groups of cells called *imaginal buds*, held in position by the tracheal system, which, together with the nervous system and mid-gut, is not destroyed. The delicate pupa thus formed, which is simply the imago with unexpanded wings, covered with a fine pupal cuticle, is called a *pupa coarctata*.

Distribution. The number of Diptera known from Australia is about 2100, from New Zealand about 1600, but the latter fauna has been more fully explored than the former*. The Nematocera are most abundant in New Zealand, where the moister conditions of the dense forest zones afford ideal conditions for such groups as Tipulidae (500 species) and Mycetophilidae (225 species); mosquitoes, however, are far more abundant in Australia than in New Zealand, where there is comparatively little standing water suitable for breeding grounds. The Brachycera, principally lovers of sunshine and open spaces, are far more abundant in Australia than in New Zealand, the Tabanidae (200 species), Asilidae (160 species), and Bombyliidae (80 species) being especially well represented. New Zealand has relatively few Asilids and Tabanids, and only a single Bombyliid is known. Empididae, on the other hand, are more numerous in New Zealand than in Australia. In the Cyclorrhapha, Tachinidae are the dominant group in both countries as regards number of species, (Australia 220, New Zealand 200), while the ubiquitous Blow-flies (Calliphorinae) make up for the smallness of the number of their species by the immense number of individuals, and are met with as abundantly on the tops of the highest mountains as they are at sea-level.

Economics. The Diptera are undoubtedly the most important Order of Insects considered in relation to man. They are the chief agents in the spread of a number of dread diseases. Mosquitoes are the carriers of malaria, yellow fever, filaria and dengue; sand-flies inflict painful bites; March-flies (Tabanidae) attack horses and cattle, and also bite man; they are suspected to be carriers of anthrax. The Stable Fly (*Stomoxys calcitrans* L.) is a vicious biter, and is known to spread anthrax also. Amongst non-bloodsucking species, the House Fly (*Musca domestica* L.) spreads filth in all directions, and is a carrier of typhoid, infantile diarrhoea and tuberculosis. Blow-flies attack and "blow" fresh and cooked meat, wool, blankets, etc., and some species cause heavy mortality amongst sheep. The larvae of Bot-flies (Oestridae) are internal parasites in horses, sheep and kangaroos. In Hippoboscidae the adult fly is parasitic on birds or mammals. Many species of Diptera do great damage to trees, fruit, cereals and vegetables of all kinds, and some damage vegetable products. The larvae of Cecidomyii-

*These totals include a number of new species from New Zealand and Tasmania shortly to be described by M. Tonnoir and Dr. Alexander.

dae, Agromyzidae and Tanypezidae make galls, mines and burrows in leaves and stems; those of *Drosophilidae* attack over-ripe fruit; those of the Trypetidae or "fruit-flies" are serious pests of citrus, tomatoes and stone-fruit; the familiar "cheese-skipper" is the larva of a small introduced Piophilid.

As against this long list of injurious species, there are few Diptera which can be classed as beneficial. Hover-flies (Syrphidae) are beneficial, in so far as many species have larvae which prey on aphids. Larvae of Tachinidae are parasitic within the bodies of other insects or their larvae, and certain species are therefore of very great value in the control of introduced injurious insects. Some Bombyliid larvae feed on the egg-masses of grasshoppers. Robber-flies (Asilidae) prey actively on other insects, and undoubtedly destroy many harmful species; but this service to man is offset by a decided taste for honey-bees. Their larvae do good work underground by destroying noxious beetle-grubs, especially those infecting sugar-cane and bananas. Details of the species of economic interest are to be found under the headings of the separate families.

Fossil History. The Diptera are one of the latest known Orders of Insects to appear in the geological record, the first forms occurring in the Upper Lias of Europe. These were archaic Nematocerous types. No Diptera are known from Australian fossil beds, but forms ancestral to the Order occur in the Upper Trias of Ipswich, in the extinct Order Paratrichoptera; these had all four wings present, the forewing similar to that of a primitive Dipteron in venation, but without the basal narrowing of the wing. This Order can in turn be derived from forms like *Parabelmontia*, a fossil wing found in the Upper Permian of Belmont, N.S.W., and placed in the extinct Order Paramecoptera, which were insects closely allied to the true Mecoptera. Both fossil and morphological evidence strongly points to a close collateral relationship between Mecoptera and Diptera, but the former Order is much closer to the ancestral type than are the Diptera.

CLASSIFICATION

The Classification of this Order is beset with many difficulties, and there is still no general agreement on the subject. Two main divisions have been proposed, both with evident advantages, but both also alike in that they do not show an entirely clear-cut division, owing to the existence of annectent forms. Some authors divide the Order primarily into Nematocera (forms with primitive antennae having more than six segments) and Brachycera (forms with shorter, specialized antennae with from six to three segments). Others would make the primary division into Orthorrhapha (forms with a pupa incompleta) and Cyclorrhapha (forms with a puparium and pupa coarctata). Certain Leptidae provide annectents for the first grouping, while the Stratiomyiidae, Platypezidae and Phoridae offer a difficulty for the second. Geological evidence shows that the original dichotomy, though not yet quite complete, was undoubtedly into Nematocera and Brachycera, and this will therefore be adopted here.

Further difficulties met with in subdividing the Suborders and Superfamilies will be dealt with under their respective headings. The characters relied upon for classification have been fully dealt with in the earlier part of this chapter, to which frequent reference should be made in following out the Keys.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order DIPTERA 2121 (1612)

Suborder NEMATOCERA 712 (914)

I. TIPULOIDEA 251 (504)
1. Tanyderidae 1 (4)
2. Tipulidae 250 (500)

II. RHYPHOIDEA 2 (3)
3. Rhyphidae 2 (3)

III. CULICOIDEA 218 (132)
4. Psychodidae 30 (40)
5. Culicidae 100 (8)
6. Dixidae 6 (7)
7. Chironomidae 75 (75)
8. Thaumaleidae 7 (2)

IV. MYCETOPHILOIDEA 100 (225)
9. Mycetophilidae 100 (225)

V. BIBIONOIDEA 41 (25)
10. Blepharoceridae 11 (8)
11. Simuliidae 14 (6)
12. Bibionidae 15 (6)
13. Scatopsidae 1 (5)

VI. CECIDOMYIOIDEA 100 (25)
14. Cecidomyiidae 100 (25)

Suborder BRACHYCERA 1409 (698)

Division *ORTHORRHAPHA* 664 (226)

VII. TABANOIDEA 282 (45)
15. Leptidae 11 (0)
16. Tabanidae 200 (15)
17. Stratiomyiidae 44 (24)
18. Cyrtidae 6 (6)
19. Nemestrinidae 21 (0)

VIII. ASILOIDEA 312 (26)
20. Therevidae 56 (10)
21. Scenopinidae 2 (0)
22. Asilidae 160 (15)
23. Apioceridae 5 (0)
24. Mydaidae 9 (0)
25. Bombyliidae 80 (1)

IX. EMPIDOIDEA 70 (155)
26. Empididae 50 (110)
27. Dolichopodidae 20 (45)

Division *CYCLORRHAPHA* 745 (472)

X. SYRPHOIDEA 97 (49)
28. Platypezidae 5 (0)
29. Phoridae 5 (15)
30. Pipunculidae 26 (4)
31. Syrphidae 60 (30)

XI. MUSCOIDEA 644 (423)

XIa. MUSCOIDEA ACALYPTRATA 302 (154)
32. Conopidae 12 (0)
33. Heteroneuridae 4 (0)
34. Scatophagidae 5 (0)
35. Helomyzidae 14 (20)
36. Phycodromidae 2 (10)
37. Sepsidae 8 (0)
38. Sciomyzidae 20 (20)
39. Sapromyzidae 41 (16)
40. Ortalidae 50 (1)
41. Tanypezidae 7 (0)
42. Trypetidae 32 (4)
43. Psilidae 2 (0)
44. Piophilidae
45. Geomyzidae 6 (12)
46. Agromyzidae 22 (16)
47. Chloropidae 41 (15)
48. Ephydridae 10 (15)
49. Drosophilidae 24 (13)
50. Borboridae 6 (12)

XIb. MUSCOIDEA CALYPTRATA 331 (268)
51. Anthomyiidae 50 (60)
52. Muscidae 60 (8)
53. Tachinidae 220 (200)
54. Oestridae 1 (0)

XII. HIPPOBOSCOIDEA 11 (1)
55. Hippoboscidae 5 (1)
56. Streblidae 1 (0)
57. Nycteribiidae 5 (0)

The two Suborders Nematocera and Brachycera may be distinguished as follows:—

Mostly slender, delicately built flies, having the antennae generally with 8-16 segments (rarely reduced to 6 or increased up t 39); maxillary palpi usually with 4-5 segments (rarely reduce or absent); wings with median cell usually absent (present i

Rhyphoidea and many Tipuloidea); Cu_1 not converging towards *1A* distally (except in some Bibionoidea). Larvae usually eucephalic or hemicephalic, seldom acephalic (only in Cecidomyiidae and one genus of Scatopsidae). NEMATOCERA

Mostly stouter, strongly built flies, the antennae with six segments or less (a few Leptidae have more than six); maxillary palpi never with more than two segments, often with one, or absent; wings with median cell usually present, (absent in Phoridae, some Empididae and a few others); Cu_1 always converging distally towards *1A* or meeting it. Larvae generally more or less acephalic (eucephalic in Stratiomyiidae) BRACHYCERA

Suborder NEMATOCERA

In addition to the above characters, it should be noted that, in the numerous forms in which *Rs* is three-branched, it is always R_{2+3} which is *branched in this Suborder, and* R_{4+5} *simple*; also that, in the larvae, numerous peripneustic forms occur, including those of the Cecidomyiidae, which are acephalous.

The Suborder may be divided into six Superfamilies, distinguished by the following Keys:—

1. Median cell present, or, if absent, then two complete anal veins are present. 2
   Median cell absent, and never more than one complete anal vein present. 3
2. Very slenderly built flies, mostly of medium or large size, with very long legs, but coxae not elongated; either four branches of *Rs* and one anal vein, or, if fewer branches of *Rs*, then two complete anal veins; Cu_1 never concave anteriorly in its distal part from *m-cu* to margin. I. TIPULOIDEA
   Medium-sized flies of less slender build, the legs normal in length, but the fore coxae very distinctly lengthened: *Rs* with two branches only; median cell always present; one complete anal and a second incomplete one; Cu_1 slightly but definitely concave anteriorly in its distal part from *m-cu* to margin. III. RHYPHOIDEA
3. Small or minute, delicate flies, with elongate moniliform antennae, small coxae, and wings with only a few main veins and apparently without cross-veins. VI. CECIDOMYIOIDEA
   Not such flies. 4
4. Coxae more or less elongated (*Rs* never with more than two branches). IV. MYCETOPHILOIDEA
   Coxae short (except in *Nemopalpus*, which has four branches to *Rs*). 5
5. Wings long and slender, or, if broader, then without any definite anal lobe; eyes of male seldom holoptic II. CULICOIDEA
   Wings short and broad, or, if longer and narrower, then with a distinct anal lobe; eyes of male frequently holoptic. V. BIBIONOIDEA

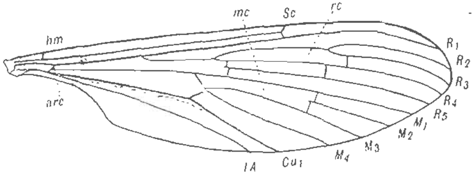


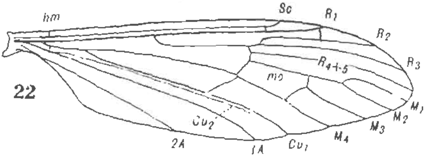
FIG. W21. Wing of *Tanyderus annuliferus* Hutt., New Zealand. Fam. Tanyderidae. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

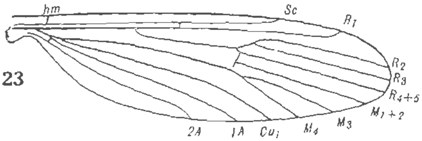
Superfamily I. TIPULOIDEA

There are two very distinct families, separated as follows:—

Mesonotum without a complete V-shaped suture; *Rs* with four branches, but only a single anal vein present. Fam. 1. TANYDERIDAE
Mesonotum with a complete V-shaped suture; *Rs* with never more than three branches, but two complete anal veins present. Fam. 2. TIPULIDAE

Family 1. **Tanyderidae** [Aus. 1, N.Z. 4]. All the species belong to the archaic genus *Tanyderus*, distinguished by its primitive venation (closely resembling that of Mecoptera, except for loss of Cu_2 and *2A*), its very slender build, long slender neck and legs, and prettily patterned wings. The best known species are the New Zealand species *T. annuliferus* Hutt. (fig. W21), and *T. forcipatus* O.S. (pl. 2, fig. 23). The genus has a closed radial cell (fig. W31, *rc*), which is not found in any other known Diptera.





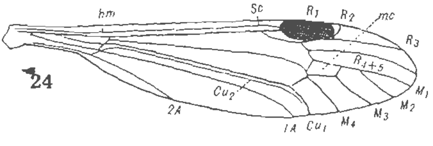


FIG. W22. Wing of ***Rhamphophila obscuripennis*** Huds., New Zealand. Fam. Tipulidae, subfam. Limnophilinae.
FIG. W23. *Wing of* ***Amphineurus insularis*** Hutt., New Zealand. Fam. Tipulidae, subfam. Eriopterinae.
FIG. W24. Wing of ***Macromastix dichroithorax*** Alex., New Zealand. Fam. Tipulidae, subfam. Tipulinae. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

Family 2. **Tipulidae** (Crane-flies, Daddy-long-legs) [Aus. 250, N.Z. 500]. This large family is well represented in both countries, but particularly in New Zealand, the Crane-fly fauna of the latter country being one of the most abundant in the world. Six subfamilies are recognized, the first five of which have short maxillary palpi (Tipulidae brevipalpi), and the fifth has them long (Tipulidae longipalpi). In this family, the median cell, when present, is always much shorter and placed further distad than in Tanyderidae. The larvae are hemicephalic, amphipneustic *or* metapneustic (fig. W14).

The Trichocerinae are an archaic group distinguished by having eucephalic larvae, a character which has led some authors to place them with the Rhyphidae.

The adult flies have the tibial spurs and venation as in Limnophilinae. New Zealand possesses twelve species of *Paracladura* and the introduced *Trichocera annulata* Meig. also occurs there.

The Limnophilinae have tibial spurs (sometimes very small) and the median cell always present. The wing of *Rhamphophila obscuripennis* Huds. (fig. W22) illustrates the venation of this subfamily well. The dominant genera in both countries are *Limnophila* and *Gynoplistia*; the latter is confined to the Australian Region, and includes a number of beautifully marked species of medium size, of which *G. bella* Walk. (pl. 20, fig. 17) is the commonest in Australia, while *G. cupraea* Huds. and *G. formosa* Hutt. are well known in New Zealand. *Cerozodia* is a remarkable genus, found in Western Australia, Tasmania and New Zealand, in which the number of antennal segments is increased to as much as 39. *Zaluscodes aucklandicus* Lamb is a peculiar, wingless form found in the Auckland Islands.

The Eriopterinae have no tibial spurs, the rostrum is not elongated, and the antennae have usually the primitive number of 16 segments. The dominant genera in both countries are *Amphineurus* (fig. W23) and *Molophilus*, both remarkable in having *mc* absent and the male hypopygium twisted through 180°. *Molophilus* contains numerous small dull-coloured species, especially abundant in New Zealand and Tasmania. *Aphrophila* contains New Zealand species which live in the spray of waterfalls and cascades, like Blepharoceridae.

The Antochinae are a small group allied to the previous one, but often with the rostrum elongated. The New Zealand species belong to *Elephantomyia* and *Ceratocheilus*, in which the rostrum is as long as the abdomen or nearly so. *Rhamphidia* and *Orimarga*, found in Australia, have a much shorter rostrum.

The Limnobiinae are distinguished by *Rs* being two-branched and the antennae with 14-15 segments. The dominant genus is *Dicranomyia* with numerous species in both countries, and is exceptionally abundant in the number of individuals occurring. *D. monilicornis* O-S. is found all over New Zealand. The genus *Discobola* contains a number of larger and finer species in New Zealand and one in Australia; they have beautifully variegated wings. *Geranomyia* and *Limnobia* are represented in Australia.

The Tipulinae are a very distinct group with long maxillary palpi and *Sc* usually ending in R_1. The dominant genus is *Macromastix* (fig. W24) in both countries; this genus also occurs in S. America. *M. costalis* Swed. is very common round Sydney in October, while in New Zealand the pale green *M. albistigma* Edw. is abundant. The handsome *M. ferruginea* Edw. (pl. 2, fig. 24) is bright orange and black, with a black stripe along the costa; it is not uncommon in parts of New Zealand. The genera *Leptotarsus*, *Ptilogyna* and *Semnotes* are peculiar to Australia: *Semnotes* contains the two largest species known there, viz., *S. ducalis* Wwd. and *S. imperatoria* Wwd. (pl. 25, fig. 1), the latter expanding nearly three inches. The largest of the New Zealand species is *Longurio dux* Huds. (pl. 25, fig. 2) which also expands nearly three inches. *Holorusia* and *Dolichopeza* also occur in both countries; *D. cinerea* Macq. is a very slender, pale testaceous species with immensely long legs, found in New South Wales. *Plusiomyia gracilis* Walk. and *Ischnotoma serricornis* Macq. are two large and handsome Australian crane-flies, both common; the former has the wing-veins marked with dark brown, the latter has both wings and body beautifully spotted with white and fuscous. The handsomest crane-flies in the world are the rare

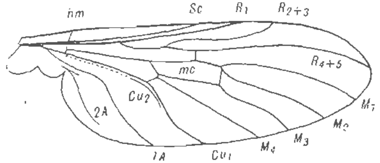


FIG. W25. Wing of *Rhyphus neozelandicus* Sch., New Zealand. Fam. Rhyphidae. Lettering as in fig. W8, p. 337. [A. Tonnoir del.

species of the genus *Clytocosmus*, confined to New South Wales, the best known being *C. helmsi* Sk. from the Monaro Plateau, and *C. tillyardi* Alex. (pl. 20, fig. 18) from the Dorrigo Scrub.

There are two New Zealand species in which the female has only vestigial wings; these are *Macromastix zeylandiae* Alex., and *Hudsonia heterogama* Huds. Similar subapterous females also occur in Australian species of the genera *Plusiomyia*, *Macromastix*, *Phymatopsis* and *Xenolimnophila*.

Superfamily II. RHYPHOIDEA

This group contains only a single family, Rhyphidae, with the characters given in the Key on p. 346. It should be noted that the concave curve of the distal part of Cu_1, found in this family alone in recent Diptera, is universal amongst the older fossil Mecoptera. Apart from the reduction of *Rs* to two branches, the Rhyphidae exhibit many archaic characters. The larvae are eucephalic and metapneustic. The Brachycera as a whole are very closely related to them, and some authors still place them within that Suborder, in spite of their antennae.

Family 3. **Rhyphidae (Anisopodidae)** [Aus. 2, N.Z. 3]. The median cell is elongated and placed in its primitive position near the middle of the wing: the formation of the whole of *M* and Cu_1 closely parallels that of the Mecoptera (figs. V3, 7). Four of the species belong to the genus *Rhyphus*; *Rh. neozelandicus* Sch. (pl. 25, fig. 3) is common in both countries. The flies are of graceful shape, with shaded wings, and are commonly found on window-panes. A single species of *Olbiogaster* occurs on Lord Howe Island and another in Australia. The larvae are eucephalic and amphipneustic (fig. W13).

Superfamily III. CULICOIDEA

In this group we include four closely related families, together with a fifth (Thaumaleidae) whose position is somewhat problematical. They may be distinguished by the following Key:—

1. *M* always with four branches; cross-veins apparently absent; mostly very hairy, usually small, moth-like flies. Fam. 4. PSYCHODIDAE
   M at most only with three branches; not such flies as above, the wings usually longer and slenderer. 2
2. *Rs* and *M* with three branches each. 3
   With fewer branches to *Rs* and *M* or both. 4
3. Main stem of *Rs* in line with R_{2+3}; wings densely clothed with hairs or scales; females mostly blood-suckers. Fam. 5. CULICIDAE
   Main stem of *Rs* not in line with R_{2+3}; wings bare; not blood-suckers. Fam. 6. DIXIDAE
4. Wings with R_{2+3} and R_{4+5} ending close together at or near apex; antennae small, about as long as palpi; eyes of both sexes holoptic. Fam. 8. THAUMALEIDAE
   Branches of *Rs* not as above; antennae longer than palpi in the males; eyes of both sexes never holoptic. Fam. 7. CHIRONOMIDAE

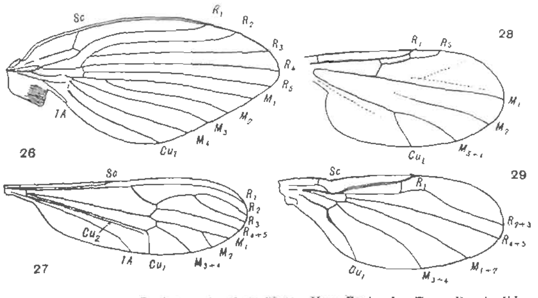


FIG. W26. Wing of *Pericoma funebris* Hutt., New Zealand. Fam. Psychodidae.
FIG. W27. Wing of *Dixa tasmaniensis* Tonn., Tasmania. Fam. Dixidae.
FIG. W28. Wing of *Ceratopogon molestus* Sk., Australia. Fam. Chironomidae.
FIG. W29. Wing of *Thaumalea* sp. indet., Australia. Fam. Thaumaleidae. Lettering as in fig. W8, p. 337. [A. Tonnoir del.

Family 4. **Psychodidae** (Moth-midges) [Aus. 30, N.Z. 40]. These graceful little flies are abundant in moist places in New Zealand, but are much less frequently met with in Australia. The subfamily Psychodinae has *Rs* 4-branched. *Psychoda conspicillata* Hutt. is the commonest species, found all over New Zealand and also in Tasmania; it is white, with slightly darker markings on the wings. *Pericoma funebris* Huds. (fig. W26) is the largest New Zealand species, expanding up to 10 mm. *P. townsvillensis* Tayl. is recorded as a biting species from N. Queensland, but an examination of its mouth-parts does not confirm this statement. Forms related to the Indo-malayan genus *Brunettia* occur in New Zealand. The Phlebotominae are biting flies, only represented by the single rare species *Phlebotomus queenslandi* Hill from N. Queensland. The Trichomyiinae, in which *Rs* is reduced to three branches, are represented by the genus *Trichomyia* in both countries and by *Sycorax* in New Zealand only.

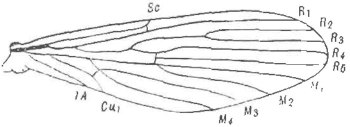


FIG. W30. Wing of *Nemopalpus zelandiae* Alex., New Zealand. Fam. Psychodidae. Length 5 mm. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

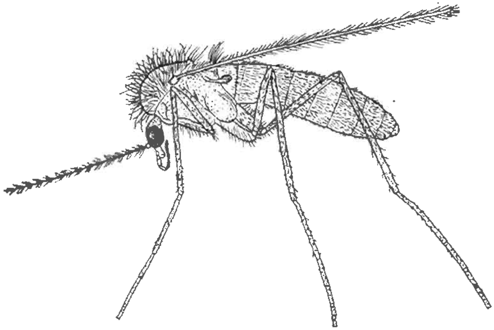


FIG. W31. *Nemopalpus zelandiae* Alex. Length 7 mm. [*A. Tonnoir del.*

Special mention must here be made of the anomalous genus *Nemopalpus*, represented by the single extremely rare New Zealand insect *N. zelandiae* Alex. (figs. W30, 31). It is a very hairy fly superficially resembling a mosquito, but the venation is allied to that of *Phlebotomus*. This genus, placed by some authors in Tanyderidae, unites that family with the Psychodidae, and is probably one of the oldest existing types of Diptera.

Family 5. **Culicidae** (Mosquitoes) [Aus. 100, N.Z. 8]. These pestilent insects are recognizable by the wings having scales, which are found only along the veins; most of them also possess a long, piercing proboscis. They are very abundant in Australia, but much scarcer in New Zealand. The presence of species of the green alga *Chara* in lakes is said to prevent the development of the larvae. The larvae, known as "wrigglers", live in still water; the slightest accumulation of water after rain suffices for some species. The pupa are active, swimming by flexing the abdomen.

The Anophelinae (absent from New Zealand) contain the genus *Anopheles* and its allies, notorious as the carriers of malaria, a disease caused by the presence of the blood-parasites of the genus *Plasmodium*. The females have long maxillary palpi and rest with the thorax in line with the rostrum, so as to appear to be standing more or less on their heads. The larvae have no siphon, and adhere horizontally to the surface-film of water by means of special palmate hairs.

The Culicinae have short maxillary palpi in the female, and rest with the thorax not in line with the rostrum. Their larvae have a siphon and rest at an acute angle to the surface-film of water. They are numerous in Australia, being chiefly represented by species of the widespread genera *Culex* and *Aedes*, the latter with many subgenera. The commonest species is *C. fatigans* Wied., which carries filariasis in Queensland; *Aedes (Finlaya) albo-annulata* Macq., *Ae. (Ochlerotatus) vigilax* Sk. and *Ae. (Finlaya) notoscripta* Sk. are common in E. Australia. *Aedes argentea* Poiret (=*Stegomyia fasciata* Fabr.) the well-known carrier of Yellow Fever, is common in the warmer parts of E. Australia, but fortunately the spirochaete (*Leptospira icteroides* Noguchi), which causes the disease, is not present; this species, however, carries dengue fever. The largest Australian species is the "Hexham Grey," *Mucidus alternans* Wwd. (fig. W32), a handsomely speckled, day-flying species, common along the eastern coastline. *Taeniorrhynchus* is represented by one or two species in New Zealand; *Culex* by two only, the commonest being *C. pervigilans* Berg. The most interesting New Zealand species

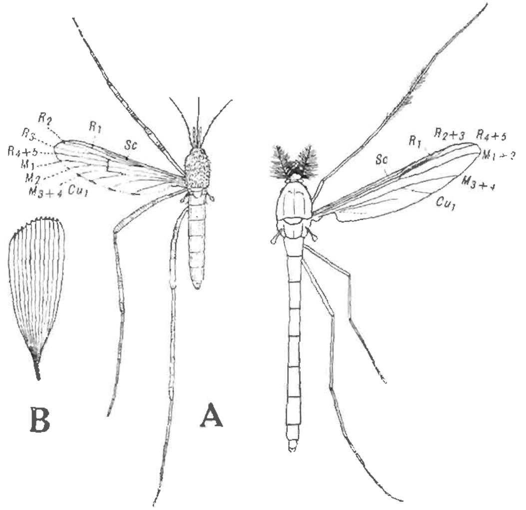


FIG. W32. A. *Mucidus alternans* Wwd., Australia. Fam. Culicidae. Length 7 mm. B, scale from wing of same, much enlarged. [*A. Tonnoir del.*
FIG. W33. *Chironomus zelandicus* Huds., New Zealand. Fam. Chironomidae. Length 7 mm. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

is the Shore Mosquito, *Opifex fuscus* Hutt., described originally as a Tipulid. The male lacks the feathery antennae found in most species, and the larva lives in sea-water on rocky coasts.

The Corethrinae are a very distinct subfamily which lack the *projecting*

proboscis, and do not bite. One species of Corethrella is known from New Zealand and one each of *Mochlonyx* and *Corethra* (*Chaoborus*) from Australia.

Family 6. **Dixidae** [Aus. 6, N.Z. 7]. The genus *Dixa* (fig. W27) occurs in both countries; *D. campbelli* Alex. is the commonest of the New Zealand species; *D. tasmaniensis* Tonn. (fig. W27) occurs throughout Tasmania. *Neodixa is a New Zealand genus containing one rare species, N. minuta* Tonn.

Family 7. **Chironomidae** (Gnats, Midges) [Aus. 75, N.Z. 75]. This family is well represented in both countries. The widespread genus *Chironomus* contains about 30 species in Australia and 10 in New Zealand. *Ch. zelandicus* Huds. (fig. W33) occurs all the year round in all parts of New Zealand, and is often exceedingly abundant. In some places, as at Lake Ellesmere, near Christchurch, this gnat may be seen, on warm, still days, forming vertical columns of considerable height and density, often for hours at a time. The small midges of the genera *Orthocladius* and *Camptocladius* are common in New Zealand; both genera also occur in Australia. The minute, biting flies of the genus *Ceratopogon*, known as "sand-flies" in Australia, are abundant along estuaries and the banks of rivers; their bites are very painful. *C. molestus* Sk. (fig. W28) is the common "sand-fly" of the New South Wales coastline, a tiny, dark midge usually not noticed until its bite is felt. *Doloplastus, Isoplastus, Procladius* and *Leptoconops* are genera peculiar to Australia. *Leptoconops stygia* Sk. is a blood-sucker, as is also the rare *Acanthoconops myersi* Tonn., found in the extreme north of New Zealand. The fine genus *Tanypus* is well represented in New Zealand by fifteen species with beautifully mottled wings; it also occurs rarely in Australia.

Family 8. **Thaumaleidae (Orphnephilidae)** [Aus. 7, N.Z. 2]. All the species belong to the genus *Thaumalea* (*Orphnephila*) (fig. W29). Their larvae are similar to those of other known species, but the pupae are remarkable in having peculiar ornamentation of the body.

Superfamily IV. MYCETOPHILOIDEA

There is only one family in this group, the Mycetophilidae, in which are included the Sciarinae, sometimes considered a distinct family. They possess primitive, rather elongated antennae and elongated coxae; the larvae are eucephalic, but have lost the metathoracic and last pair of abdominal spiracles. Some of the pupae are enclosed in a silken cocoon. The wing-venation is specialized by reduction of *Rs* to two branches or less, reduction of *Sc*, and secondary attachments of *M*; usually M_{1-2} becomes attached to *Rs*, and M_{3+4} (unbranched) to Cu_1, making the latter appear a forked vein.

Family 9. **Mycetophilidae** (Fungus-gnats, Shade-midges) [Aus. 100, N.Z. 225]. These pretty, delicate gnats are exceptionally abundant in New Zealand; the presence of so many moist, shady localities is very favourable for their development. In Australia they are not so generally abundant either in individuals or in species.

The Sciarinae are distinguished by the moderately elongated coxae, and by having M_{3+4} arising from Cu_1 very near the base of the wing (fig. W34). There are about 50 species in Australia, but only 14 in New Zealand, mostly belonging to the dominant genus *Sciara*. *Trichosia* is represented by a few species in both countries, and *Zygoneura* by one or two in Australia.

The Diadocidinae are a small group which include the remarkable forms whose larvae are known as "glow-worms" in both countries. These slender, elongate larvae spin webs in damp crevices and on the faces of moist rocks and move with great agility. Some of the colonies are of great size and are justly famous, notably those at Bundanoon, New South Wales, and the Waitomo Caves, New Zealand. The New Zealand species is *Arachnocampa luminosa* Sk., and was originally placed in the genus *Bolitophila*.

The following beautiful account of the Glow-worm Cave at Waitomo, N.Z. has been given by Mr. C. L. Edwards (entry in dairy, May 9th, 1923, quoted by F. W. Edwards, Ann. Mag. Nat. Hist., 1924, xiv, pp.178-9) :—"After due admonitions, and obeying the order to leave all lamps behind, we stepped cautiously in single file down, down to a still lower level. Collecting ourselves at an unseen bottom, we held each one his breath, and listened. To each in turn a whisper floated, "Get into the boat" . . . . Then, gradually we became aware that a vision was silently breaking on us. Either we were moving (though without oars) or a panorama was passing before us. I recollect just noticing the glint of a wire which might have been fastened along the wall of the cave, and on which our dumb boatman might be pulling. But, at any rate, a radiance became manifest

which absorbed the whole faculty of observation,—the radiance of such a massed body of glow-worms as cannot be found anywhere else in the world, utterly incalculable as to numbers and merging their individual lights in a nirvana of pure sheen.

"And now as to the disposition of this mystic light, which produced itself all unaided in innumerable points. The cave was evidently similar in structure

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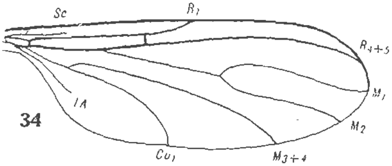

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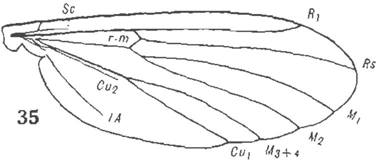

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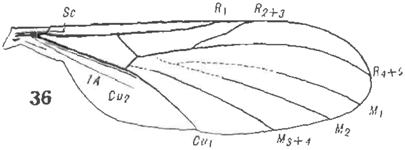


FIG. W34. Wing of *Sciara aemula* Sk. (after Skuse), Australia. Fam. Mycetophilidae, subfam. Sciarinae. [*A. Tonnoir del.*

FIG. W35. Wing of *Mycetophila robusta* Marsh. New Zealand. Fam. Mycetophilidae, subfam. Mycetophilinae. [*A. Tonnoir del.*

FIG. W36. Wing of *Nervijuncta wakefieldi* Sch., New Zealand. Fam. Mycetophilidae, subfam. Ceroplatinae. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

to all the others, giving an endless variety of outline; but whatever was there became dotted over with points of golden light as closely studded as the letters on a printed page, a truer parallel than the glibly quoted starry sky. It did strike me, however, that the higher reaches of the cave resembled the Milky Way. But from those heavens stretched down wondrous stalactites all clothed in living light, and appearing like arms ready to lift one right up to those far-away stars; and not only above the main silent river, along which our noiseless way was truly a gliding, but in branching fjords surprise burst on us again and again, revealing fascinating vistas of the same glowing and shapely splendour. To bow the head in adoration of Beauty was but to meet its whole shimmer reflected, unwrinkled, in the quiet river below."

The Macrocerinae are another small group represented only by *Macrocera* in both countries. *M. decorosa* Sk. (pl. 20, fig. 19) is a beautifully marked Australian species.

The Mycetophilinae are the dominant subfamily, and have the coxae very

elongated and M_{3+4} arising from Cu_1 far from the wing-base (fig. W35). Most of the species belong to *Mycetophila, Zygomyia, Aphelomera* and *Centrocnemis*; they are particularly abundant in New Zealand.

The Ceroplatinae have *Rs* and M_{1+2} fused for a short distance basally. *Platyura* and *Ceroplatus* occur in both countries. *Nervijuncta* (fig. W36) is a fine genus peculiar to New Zealand; the species are of comparatively large size, with holoptic eyes in both sexes. The male of *N. hudsoni* Hutt. (pl. 25, fig. 4) has the wings of very peculiar shape.

Superfamily V. BIBIONOIDEA

In this family we have placed four families related by the form of their wing-venation, the short coxae, the frequent occurrence of holoptic eyes and also of eyes divided into two distinct parts having different types of facets. The two terrestrial families, Bibionidae and Scatopsidae, are very closely related; the Simuliidae are aquatic but of distinct Bibionoid build; the waterfall-dwelling Blepharoceridae are a very distinct family whose relationships are more doubtful, but which share with the Simuliidae the character of having the wings folded in the pupal stage. These families may be separated as follows:—

1. Slender, long-legged flies, dwelling on or around waterfalls and cascades, and having a secondary net-veining of the wings. — Fam. 10. BLEPHAROCERIDAE
   Not such flies. — 2
2. Cross-veins *r-m* and *im* present: a long cell open to base and closed by *im* is present between *M* and Cu_1 — Fam. 12. BIBIONIDAE
   Apparently no cross-veins present; the long cell also absent. — 3

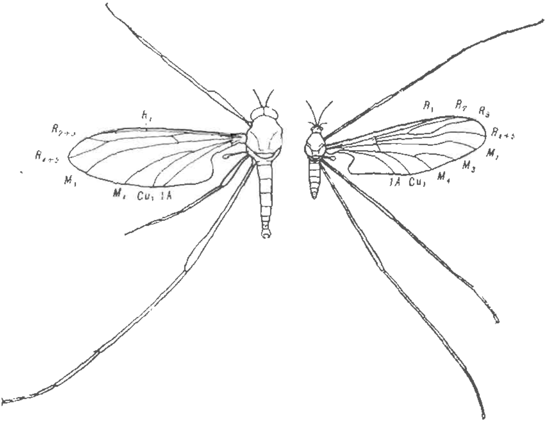


FIG. W37. *Neocurupira hudsoni* Lamb, male, New Zealand. Fam. Blepharoceridae. Length of wing, 9 mm.

FIG. W38. *Edwardsina tillyardi* Tonn., female, Australia. Fam. Blepharoceridae. Length of wing, 11 mm. Lettering as in fig. W8, p. 337.

Note the presence of the basal piece of M_{2+3} in *Edwardsina*. The loss of this in *Neocurupira* leaves M_4 stranded on to Cu_1.

[*A. Tonnoir del.*

3. Stoutly built flies, aquatic; stems of *Sc*, *R* and M_{1+2} separate but close together. — Fam. 11. SIMULIIDAE
   Usually slenderer and much smaller flies, terrestrial; stems of *Rs* and M_{1+2} fused together. — Fam. 13. SCATOPSIDAE

Family 10. **Blepharoceridae** (Net-veined Midges) [Aus. 11, N.Z. 8]. These delicate flies are not uncommon in New Zealand on the numerous fast-running streams; most of the Australian species are found in Tasmania (six species) and on the Southern Alps and Blue Mts. The most archaic genus known is *Edwardsina*, confined to South America, Tasmania, and Mt. Kosciusko, N.S.W. The venation is remarkable in still retaining the original stem of M_{3+4} (fig. W38), thus affording a clear explanation of the reduced venation of the rest of the family. All the species show a beautiful, violet iridescence on the wings. *E. tillyardi* Tonn. (fig. W38) is a fine species expanding nearly an inch, found on Mt. Kosciusko, where also the slightly smaller and duller *E. australiensis* Till. occurs commonly. All the Tasmanian species belong to this genus. *Neocurupira* and *Paracurupira* are two closely related genera found in New Zealand, with *Rs* apically forked. *N. hudsoni* Lamb (fig. W37) is a fine species expanding nearly an inch, and found only in the South Island of New Zealand. The smaller *N. nicholsoni* Till. occurs on Mt. Kosciusko, Australia. *Peritheates* is peculiar to New Zealand; it has *Rs* unbranched. *Apistomyia*, with *Rs* unbranched and bent upwards, ranges from Australia through Ceylon to South-eastern Europe.

These flies have the mouth-parts very complete, the females having spear-like mandibles (fig. W2); they attack other flies on the wing. Their larvae are extraordinary objects provided with a row of six ventral suckers by means of which they cling to rocks beneath rushing water (fig. W15). Their pupae are black, oval objects attached to the same spots by means of three pairs of pads, and breathing by means of lamellate organs attached to the prothorax (fig. W19).

Family 11. **Simuliidae** (Sand-flies) [Aus. 14, N.Z. 6]. The true Sand-flies, also called "Buffalo-gnats" in America, are one of the greatest pests in New Zealand, where they swarm in the neighbourhood of all running streams, and bite viciously from morning to evening. All six species are very closely related and only reliably to be distinguished by the form of the gill-filaments of the pupae; they all belong to the genus *Austrosimulium*, with 10-segmented antennae. *A. australense* Sch. is the commonest species in the North Island.

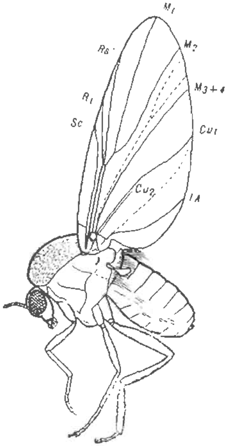


FIG. W39. *Simulium aurantiacum* Tonn., female, Australia. Fam. Simuliidae. Length of body, 5 mm. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

In Australia fourteen species are now known, but they are not very common. *Simulium aurantiacum* Tonn. (fig. W39) is a fine species with reddish-orange thorax,

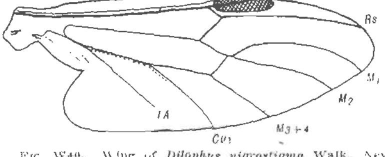


FIG. W40. Wing of *Dilophus nigrostigma* Walk., New Zealand. Fam. Bibionidae. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

found in shady gullies in Eastern Australia. The larvae live in colonies on rocks in running water; they form beautiful silken cocoons, open anteriorly, within which they pupate, the gill-filaments of the pupa projecting from the open end.

Family 12. **Bibionidae** [Aus. 15, N.Z. 6]. All the New Zealand species belong to the genus *Dilophus* (fig. W40), which also occurs in Australia. The genus *Bibio* occurs in Australia, *B. imitator* Walk. being the commonest species. Several well-marked species of *Plecia* are also found; *P. dimidiata* Macq., with black body, red thorax and smoky wings, is very common. The larvae of this family live in the soil.

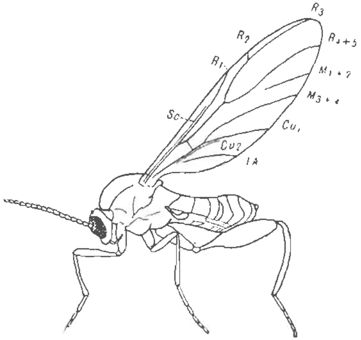


FIG. W41. *Canthyloscelis antennata* Edw., male, New Zealand. Fam. Scatopsidae. Length 7 mm. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

Family 13. **Scatopsidae** [Aus. 1, N.Z. 5]. Two species of *Scatopse* are known in Australia, but one of these, *S. notata* L., is an introduction from Europe. In New Zealand one native species, *S. carbonaria* Hutt., has been described. They are very small flies. New Zealand also possesses four species of the very curious genus *Canthyloscelis* (fig. W41), much larger and very unlike *Scatopse* in appearance, and having very peculiar venation and curiously shaped hind-legs. Their larvae live in rotten wood, and are the only acephalous larvae known in the superfamily Bibionoidea.

Superfamily VI. CECIDOMYIOIDEA (OLIGONEURA).

This group contains only the isolated and reduced family Cecidomyiidae, easily recognized by the small coxae, the elongated, moniliform antennae and the wings with only a very few main veins (often only two or three). The most frequent number of antennal segments (30) appears to have arisen by secondary division of each primitive flagellar segment into two. They are all small, delicate midges, having acephalic but peripneustic larvae, many of which form galls on the stems and leaves of plants, while others live more freely on plants or in wood.

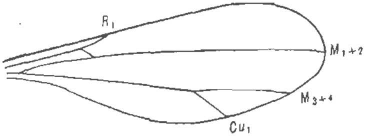


FIG. W42. Wing of *Diplosis* sp. indet., Australia. Fam. Cecidomyiidae. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

Family 14. **Cecidomyiidae** (Midges, Gall-gnats) [Aus. 100, N.Z. 25]. Most of the species belong to such world-wide genera as *Cecidomyia*, *Lestremyia*, *Epidosis*, *Diplosis*, *Miastor* and *Campylomyza*, all represented by a number of species in both countries. About half the Australian species belong to *Diplosis* (fig. W42). Galls formed by these insects are common objects in most countries, but in Australia they are by no means so conspicuous or abundant as the numerous galls formed by Coccids. True Cecidomyiid galls have been found on eucalypts, wattles, tea-tree and other plants, but only a few of the complete life-histories are known. The most noticeable are the little red spherical galls formed along the midrib of eucalyptus leaves by *Harmomyia omalanthi* Sk.

Several species have been introduced from Europe. One of these, the Pear Leaf-curling Midge, *Perrisia pyri* Bouché, is causing great damage to pear-trees in the Auckland, Hawke's Bay and Nelson provinces of New Zealand. The eggs are laid in the young, curled leaves, and the larvae suck the sap, causing the leaf to remain curled, hardened and blackened. Several broods succeed one another during the summer, and entirely prevent the growing of young trees. Another serious pest, introduced into New Zealand from America, is the Hessian Fly, *Cecidomyia destructor* Say, which damages wheat fields. The strenuous measures taken to check this pest have met with success; but it is to be hoped that it will not reach Australia, where its opportunities for destructiveness would be very greatly increased.

Suborder BRACHYCERA

In this Suborder are included all those Diptera in which the antennae consist of six segments or less. The great majority of forms have antennae with only three well-marked segments; the third segment, however, is often constricted into from two up to eight separate portions, called annuli or annulations, while in many groups it carries a terminal or dorsal style or arista, either unsegmented or having two or three segments. The venation is characterized by the presence (with few exceptions) of the median cell, by R_{2+3} being always simple, and by Cu_1 either converging strongly towards, or fusing distally with, $1A$. The maxillary palpi are almost always composed of a single segment, rarely two-segmented, never more. Some Leptid genera form, as regards their antennae (having more than six true segments) annectent genera with the Nematocera, but are otherwise true Brachycera; such forms are not to be found in Australia or New Zealand.

The Suborder contains two large Divisions, as follows:—

No frontal lunule or ptilinum present on head; pupa not enclosed in larval skin (except in Stratiomyiidae). *ORTHORRHAPHA*

A frontal lunule and ptilinum present on head; pupa enclosed in the hardened larval skin, which forms an oval, barrel-like puparium. *CYCLORRHAPHA*

Division *ORTHORRHAPHA*

This Division contains thirteen families, which can be separated into three distinct Superfamilies as follows:—

1. Below the tarsal claws is a triple pad, formed of the two pulvilli and a pad-like empodium (fig. W6); always smooth flies without any bristles. VII. TABANOIDEA

   Never a triple pad below the claws, empodium absent, or, if present, only bristle-like; flies with or without bristles. 2

2. Cu_1 and $1A$ complete (except in a few Cyrtidae and Bombyliidae) Cu_1 bent distally downwards so as to meet $1A$ at or near its end (one-third from end in Scenopinidae) or reaching the wing-margin very close to $1A$. VIII. ASILOIDEA

   Cu_1 reduced in length and much curved distally, so as to meet $1A$ usually before half-way or close to base; sometimes both these veins greatly reduced or even eliminated; venation never complete, M never with four branches and Sc frequently much reduced. IX. EMPIDOIDEA

Superfamily VII. TABANOIDEA

This group contains five very distinct families, easily separated by the following Key:—

1. Venation very complex; R_{4+5} partially fused with M_{1+2}, and the five veins from R_{2+3} to M_2 inclusive all ending up close together before the

apex of the wing (except in *Exeretoneura*, in which M_1 ends below apex). Fam. 19. NEMESTRINIDAE

Venation not of the above type. 2

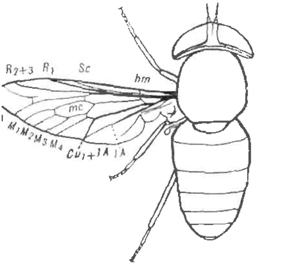


FIG. W43. *Tabanus circumdatus* Walk., Australia. Fam. Tabanidae. Length 14 mm. [*A. Tonnoir del.*

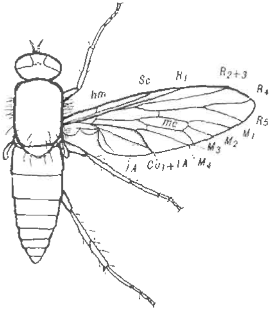


FIG. W44. *Anabarrhynchus montanus* White, New Zealand. Fam. Therevidae. Length 12 mm. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

2. Head small; thorax hump-backed, bladder-like, immensely swollen; squames enormous. Fam. 18. CYRTIDAE
   Not such flies. 3

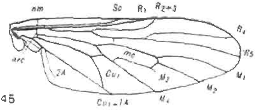
3. Median cell small and compact, the branches of *M* weak and often not *reaching the margin of the wing; scutellum often armed with spines;* abdomen flattened. Fam. 17. STRATIOMYIIDAE
   Median cell normally elongate, the branches of *M* normal, reaching the wing-margin; scutellum unarmed; abdomen convex. 4

4. Usually stoutish flies with the head broad and flattened transversely; squames rather large; proboscis moderate to long; females with spear-*like mandibles, blood-suckers.* Fam. 16. TABANIDAE
   Slenderer flies with narrower head; squames small or rudimentary; proboscis short; females without mandibles and not blood-suckers (except *Spaniopsis*). Fam. 15. LEPTIDAE

Family 15. **Leptidae** [Aus. 11, N.Z. 0]. A small family, represented by ve genera in Australia; absent from New Zealand. The biting flies of the genus *paniopsis* (fig. W45), *resembling small March-flies, but with very short proboscis* ıd narrow heads, are an annoyance in the bush in the autumn. *S. longicornis erg. (pl. 25, fig. 5), from the Blue Mts., is the largest species, 6 mm. long;* ey are dark fuscous flies, faintly banded with grey. *Chrysophilus aequalis* Walk. a common species with large rounded head and holoptic eyes in the male. The her genera are *Atherimorpha, Dasyomma* and *Austroleptis.*

Family 16. **Tabanidae** (March-flies, Horse-flies, Gad-flies, Cleggs) [Aus. 0, N.Z. 15]. A very extensive family, easily recognized by the strong, straight oboscis, the wide, subtriangular head and the three-segmented antennae, the ird segment having from 4 to 8 annulations; the venation is normal and similar that of the Leptidae. The larvae are subcylindrical, fleshy, aquatic, carnivorous, ıd have rings of peculiar pseudopod-like processes on the abdomen.

There are two distinct subfamilies, of which the more primitive Pangoniinae, *ving tibial spurs on the hind legs, are especially well represented in Australia. lecorrhynchus* is a fine genus, chiefly confined to the mountains of Tasmania and Australia, from which eighteen species are known; there are also three in ıili. They are handsome flies, with a strong, hatchet-shaped proboscis incapable



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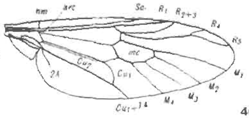

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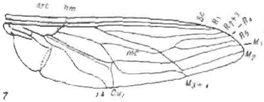

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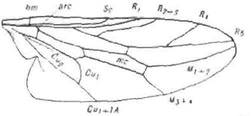

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Fig. W45. Wing of *Spaniopsis longicornis* Ferg., Australia. Fam. Leptidae.
Fig. W46. Wing of *Neoexaireta spinigera* Wied., Australia. Fam. Stratiomyiidae.
Fig. W47. Wing of *Trichophthalmus novae-hollandiae* Macq., Australia. Fam. Nemestrinidae.
Fig. W48. Wing of *Scenopinus* sp. indet., Australia. Fam. Scenopinidae. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

of piercing the human skin: *P. fulvus* Ric. and P. *nigripennis* Ric. are shown in pl. 20, figs. 20, 21 respectively. The peculiar allied genus *Apatolestes* has one species in New Zealand and one in S. America. *Osca* (*Diatomineura*), with 24 species in Australia and three in New Zealand, is the dominant genus of the subfamily; *O. auriflua* Don. is a handsome species with green eyes and patches of rich golden hair on the body, found on mountains, while *O. concolor* Walk., *O. subappendiculata* Macq. (pl. 25, fig. 6) and *O. maculiventris* Wwd. are larger brownish species found at low altitudes. *O. bicolor* Hutt. is not uncommon in New Zealand. Many of these species have a long, slender proboscis. The genus *Erephopsis* contains the finest species of all; *E. guttata* Don. (pl. 25, fig. 7) is a huge, stout fly nearly an inch long, black marked with white spots on abdomen; it rests on tree-trunks in the coastal forests of E. Australia, and does not attempt to bite. *E. adrel* Walk. is a fine New Zealand species, commonly met with hovering in the air or visiting the blossoms of manuka (*Leptospermum*). The widespread genera *Silvius* and *Chrysops* are also found in Australia. No less than nine genera of this subfamily are peculiar to Australia, viz., *Apocampta*, *Ectenopsis*, *Demoplatus*, *Pseudotabanus*, *Coenoprosopon*, *Palimmecomyia*, *Phibalomyia*, *Parasilvius* and *Pseudopangonia*, each having only one or two described species.

The subfamily Tabaninae, having no spurs on hind tibiae, is represented by a single species of *Cydistomyia* and one of *Paracanthocera* in Australia, and by an immense number of species of the great genus *Tabanus*, of which 112 species are known from Australia, 8 from New Zealand. They are especially abundant in low, swampy districts in tropical or subtropical parts, and are a continuous annoyance to cattle and horses, which they bite viciously on the legs and flanks: they also attack human beings, biting them on the legs and hands. *T. circumdatus* Walk. (fig. W43) and the smaller *T. regis-georgii* Macq. are common species with banded abdomens; the reddish-brown *T. sanguinarius* Big., the black *T. victoriensis* Ric., and the dark *T. alternatus* F. & H. with shaded wings are all much larger, well-known species. In New Zealand *T. impar* Walk., T. *sordidus* Walk. and other species are found resting on rocks in river-beds; they seldom appear to bite.

Family 17. **Stratiomyiidae** (Soldier-flies) [Aus. 44, N.Z. 24]. This family is easily recognized by the flattened abdomen, the usually armed scutellum and the small median cell of the wing (fig. W46); the antennae have three well-marked segments and a slenderer terminal portion (often annulated). The larvae are strap-like (fig. W16), aquatic or living in damp earth, and the pupa is formed inside the unchanged larval skin.

The Berinae contain species having seven visible abdominal segments. The genera *Actina* and *Beris* are brilliantly metallic in colour. *Neoexaireta spinigera* Wied. (pl. 25, fig. 9) is a shining black fly with shaded wings, very common about houses in Australia and also in New Zealand, where it has probably been

introduced. *N. apicalis* Hutt. (pl. 2, fig. 25) is somewhat smaller, with reddish abdomen; it is common in New Zealand, sitting on tree-trunks. The allied Chiromyzinae include the well-known *Metoponia rubriceps* Macq., a small, dull species whose larvae are found in lawns in Sydney and Brisbane, and the remarkable *Boreoides subulatus* Hardy (pl. 25, figs. 10, 11), found chiefly at high altitudes in South-eastern Australia, in which the female is much larger than the male and entirely wingless.

The remaining subfamilies have only 5-6 visible abdominal segments. Of these we may mention the Sarginae and Hermetiinae, which have no spines on the scutellum, and the Pachygasterinae, which have one branch of *M* missing; all are rather poorly represented in our fauna. The Stratiomyiinae and the allied Clitellarinae, both with spines on the scutellum, are better represented, the commonest genus being the well-known *Odontomyia* (Stratiomyiinae) with wide head, broadly flattened abdomen and venation obsolescent apically. The commonest species are *O. decipiens* Guer. (pl. 25, fig. 8) in Australia, *O. atrovirens* Big. in New Zealand; these flies are often seen hovering motionless in the air on warm sunny days; the abdomen is usually marked laterally with green or yellow.

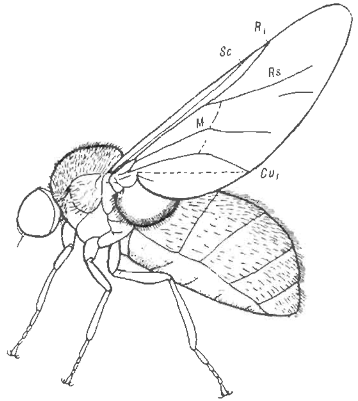


FIG. W49. *Oncodes brunneus* Hutt., New Zealand. Fam. Cyrtidae. Length 5 mm. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

Family 18. **Cyrtidae (Acroceridae)** (Bladder-flies) [Aus. 6, N.Z. 6]. These extraordinary flies have very diverse venation, but can all be recognized at once by the swollen, bladder-like thorax, the huge squames, and the small head. Some have a very long, slender proboscis. The larvae are parasitic on spiders. *Panops baudini* Lam. (pl. 25, fig. 12), is the largest Australian species, olive brown with shaded wings. *Pterodontia mellei* Er. is a fairly large, greatly inflated form, with the costa of the wing angulated. *Oncodes basalis* Walk. is a smaller, dark species, with normal costa and moderately swollen thorax; *O. brunneus* Hutt. (fig. W49) and *O. nitens* Hutt. are not uncommon in New Zealand. The handsomest of all is the metallic blue *Apsona muscaria* Wwd. (pl. 2, fig. 26), which closely resembles a Bombyliid, hovering motionless on the air and emitting a shrill note; it is only found on the Dun Mt. and Tararuas in New Zealand. Another rare New Zealand species is the slenderly built *Helle longirostris* Huds., also not unlike a Bombyliid.

Family 19. **Nemestrinidae** [Aus. 21, N.Z. 0]. A small family with unmistakable venation (fig. W47); absent from New Zealand. The species are chiefly found in Australia and South America. Of the Australian species, the com-

monest are those of the genus Trichophthalmus, having a large, almost hemispherical head and hairy eyes. *T. novae-hollandiae* Macq. (fig. W47) is dull brown, expanding 40 mm.; *T. nigripes* Macq. (pl. 25, fig. 13) is closely similar, but has black hind legs and yellow pubescence around *scutellum and on sides of thorax.* Other Australian genera are *Trichopsidea*, *Exeretoneura* and *Nycterimyia.*

Superfamily VIII. ASILOIDEA

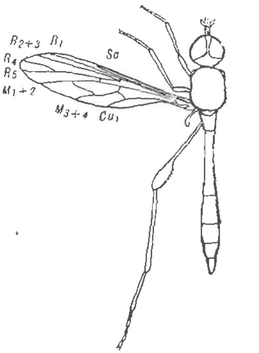


FIG. W50. *Systropus clavifemoratus* Hardy, Australia. Fam. Bombyliidae, subfam. Systropinae. Length 10 mm. [*A. Tonnoir del.*

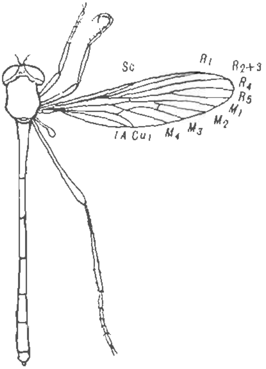
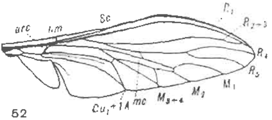


FIG. W51. *Leptogaster antipodum* Big., Australia. Fam. Asilidae, subfam. Leptogasterinae. Length 12 mm. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

This is a group of flies having the venation on the whole on the same plan as in the Tabanoidea (but somewhat reduced in Scenopinidae), but distinguished by never having a pad-like empodium, and hence never a triple pad beneath the claws (fig. W7); the empodium is either bristle-like, reduced or absent. There *are six families, separated as follows:—*

1. Cu_1 strongly bent distally, fusing with *1A* at one-third from apex of latter vein; *M* with only two branches; *Sc*, R_1 and R_{2+3} all short and close together. Fam. 21. SCENOPINIDAE
   Venation not as above; Cu_1 either meeting the wing-margin close to the end of *1A*, or fusing with the latter near its tip; *M* seldom with *only two branches;* R_{2+3} usually long. 2
2. R_5 terminates before the apex of the wing. 3
   R_5 terminates beyond (rarely at) the apex of the wing 4
3. Antennae 3-segmented, with or without a terminal style; *bristly flies.* Fam. 23. APIOCERIDAE
   Antennae 4-segmented, the fourth seg. always long; smooth flies. Fam. 24. MYDAIDAE
4. Front excavated between the well-separated eyes; proboscis a hard, piercing beak. Fam. 22. ASILIDAE
   Front not excavated; proboscis not of above type. 5
5. *M* with four branches, of which the last two converge closely or fuse distally; usually bare flies; eyes of moderate size, separate or touching. Fam. 20. THEREVIDAE
   M with only two or three branches present; usually either R_{2+3} or R_4 or both turned up distally; usually woolly flies; eyes large, generally *fused in male.* Fam. 25. BOMBYLIIDAE

Family 20. **Therevidae** [Aus. 56, N.Z. 10]. These flies look like rather small Robber-flies without the hard beak and strongly built legs; the proboscis is short and fleshy, with broad labella; maxillary palpi with two segments; the legs slender, bristly, without empodium but usually with pulvilli; venation of the



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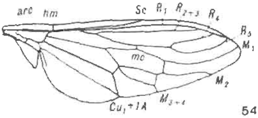

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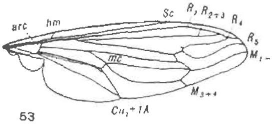

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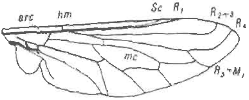

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FIG. W52. Wing of *Neoaratus hercules* Wied., male, Australia. Fam. Asilidae, subfam. Asilinae.
FIG. W53. Wing of *Miltinus viduatus* Wwd., Australia. Fam. Mydaidae.
FIG. W54. Wing of *Apiocera asilica* Wwd., Australia. Fam. Apioceridae.
FIG. W55. Wing of *Systoechus crassus* Walk., Australia. Fam. Bombyliidae, subfam. Bombyliinae. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

normal type found in Leptidae, Tabanidae and most Asilidae. All the New Zealand species and many of the Australian belong to the dominant genus *Anabarrhynchus*. *A. bilineatus* Fabr. and *A. montanus* White (fig. W44) are common in New Zealand. *Ectinorrhynchus variabilis* Macq. is a common Australian species of variable coloration, with the apex of the wing shaded brownish; *E. viduus* Sch. (pl. 25, fig. 14) has two blackish fasciae on the wings, and, in the female only, the apical fourth is bright orange. *Psilocephala* and *Phycus* are also found in Australia, while there are numerous endemic genera. *Agapophytus albopunctatus* Roder (pl. 25, fig. 15) is jet black with bright orange wings and long black antennae; under a lens the thorax is seen to be finely pitted all over with tiny white spots. The larvae of this family are long, slender, cylindrical grubs with the body apparently 19-segmented; actually six of the abdominal segments are secondarily divided into two parts; they live in sand, soil, rotten wood, etc., and prey on other larvae.

Family 21. **Scenopinidae** [Aus. 2, N.Z. 0]. A small family much resembling the foregoing, and having the same type of larva, but with the venation considerably reduced (fig. W48), as indicated in the Key on p. 361. One species of each of *Scenopinus* and *Pseudatrichia* are recorded from Australia.

Family 22. **Asilidae** (Robber-flies) [Aus. 160, N.Z. 15]. Mostly medium to large flies of rather slender build, elongated abdomen, strong, bristly legs, the vertex excavated between the dichoptic eyes, the face with a conspicuous beard, the proboscis a hard beak used for spearing other insects captured on the wing; the empodium may be absent or bristle-like. Venation mostly of normal type, but sometimes slightly specialized (fig. W52). The larvae of Asilidae are active, cylindrical grubs, usually creamy-white in colour, predaceous on, or even parasitic in, other larvae; they are found in soil, rotten wood, etc. This is the dominant family of the group. Four subfamilies are usually recognized; all occur in Australia, but the Laphriinae are absent from New Zealand.

The Dasypoginae have R_{2+3} ending normally on the wing-margin (marginal cell open). *Saropogon* is a typical genus with numerous species in both countries. *Bathypogon* has short wings and very bristly legs. A group of wasp-mimicking forms belonging to this subfamily occur in Australia: they belong to the genera *Cabasa*, *Codula*, *Chrysopogon* and *Neosaropogon*. They have bodies banded in black and orange, and the legs and wings are often orange also. The fine *Chrysopogon crabroniformis* Roder is shown in pl. 20, fig. 23; *Neosaropogon princeps* Macq. is slenderer, with orange wings slightly clouded apically; *Codula vespi-*

formis King is smaller, with a black band along the costa of the wing (pl. 20, fig. 22). All these flies are easily mistaken on the wing for wasps. The giants of the subfamily belong to the genus *Phellus*, ranging from Western to Eastern Australia; the best known, *Ph. glaucus* Walk. (pl. 25, fig. 16) is easily recognized by its immense beard and by the steely blue-black abdomen clothed with tufts of creamy or yellowish hairs.

The Leptogasterinae contain a number of small and very slender species of the genus *Leptogaster* with narrow, petiolate wings without an alula. *L. geniculata* Macq., *L. fumipennis* White and *L. antipodum* Big. (fig. W51) are not uncommon in Eastern Australia and Tasmania.

The Laphriinae have R_{2+3} ending on R_1 (marginal cell closed), and the antennae are 3-segmented without a terminal style; the chief genera found in Australia are *Laphria*, *Metalaphria*, *Thereutria*, *Nusa* and *Maria*. *Thereutria amaraca* Walk. is a common species, black with black and reddish legs; *Laphria clavata* Wh. (pl. 25, fig. 17) is entirely black, with clouded wings.

The Asilinae are the dominant subfamily; they have R_{2+3} as in Laphriinae but the antennae end in a terminal style or bristle. The genus *Asilus* and its offshoots *Neoaratus*, *Pararatus* and *Neoitamus* are well represented in Australia; *Asilus* and *Neoitamus* also occur in New Zealand. *Neoaratus hercules* Wied. is the finest of this group; it is 35 mm. long, dull brownish, and not uncommon on grassy slopes near the coastline; the male has the costa strongly arched at the pterostigma, with a wide, transversely corrugated space between R_1 and R_{2+3} (fig. W52). *Asilus rufiventris* Macq. is nearly as large, of a richer brown, and with the venation of the male normal. Several other species of this genus measuring an inch or so in length are quite common, while the smaller and slenderer species of *Neoitamus* abound in the bush, and are also the commonest robber-flies in New Zealand. *Ommatius angustiventris* Macq. is a handsome blackish species about 20 mm. long with yellow tibiae. The finest of all known Asilidae belong to the Australian genus *Blepharotes*. *B. coriareus* Wied. (pl. 20, fig. 24) is 35 mm. long, expands 3 inches, and has a black head and thorax, a broad orange abdomen with black and white tufts of hairs, and smoky black wings. *B. splendidissimus* Wied. (pl. 25, fig. 18) is not quite so large, but has very broad abdomen, bronze-green in colour, and variegated wings; both species occur somewhat rarely in Eastern Australia.

Family 23. **Apioceridae** [Aus. 5, N.Z. 0]. A small family of rather large flies resembling Therevidae and Asilidae, but distinguished by having R_4, R_5 and M_1 all turned up distally so as to end before the apex of the wing. R_{2+3} and even sometimes R_4, end up on R_1, and there is always (as also in some Asilidae, e.g. *Laphria*) a closed cell below the true median cell, formed by fusion of M_3 and M_4 distally (fig. W53). The proboscis is short and fleshy, bristles are present on the thorax, the empodia are absent, the abdomen is broad basally, tapering distally, and the male has a large genital forceps. All the Australian species belong to the genus *Apiocera*. *A. asilica* Wwd. (pl. 25, fig. 19) is nearly an inch long, dark brownish with grey pubescence beneath; *A. bigoti* Macq. is somewhat smaller, paler brown mottled with grey, and with the veins of the wings reddish.

Family 24. **Mydaidae** [Aus. 9, N.Z. 0]. A small family of large, handsome flies which apparently mimic Psammocharid wasps; they superficially resemble Robber-flies, but can be at once distinguished from them by the short, fleshy proboscis, the four-segmented and usually long antennae without a terminal style, and by the venation being similar to that of Apioceridae, but with the wings broader; in addition to the branches of *Rs* and M_1, M_2 also bends upwards distally and ends well before apex (fig. W54). The Australian species belong to the genera *Miltinus* (*Triclonus*) and *Diochlistus*. *M. viduatus* Wwd. (pl. 25, fig. 20) is a handsome, shiny black species with the wing-veins clouded; *D. aureipennis* Wwd. (pl. 20, fig. 25) is a very fine species with black thorax, orange wings and abdomen, and very elongated, orange antennae

Family 25. **Bombyliidae** (Bee-flies) [Aus. 80, N.Z. 1]. The members of this family are exceedingly variable in shape, the popular name "Bee-flies" being only rightly applicable to the genus *Bombylius* and its allies. They are often very woolly flies, and can be recognized by the large, more or less hemispherical head, with holoptic eyes in the males, the slender legs without bristles and with very small claws and no empodium, and particularly by the reduced venation, *M* never having four branches, and R_4 always curving upwards to end before apex (fig. W55). The larvae are parasitic on the eggs or larvae of other insects. About 150 species have been named from Australia, but Hardy has shown that only

about 80 of these are valid species; New Zealand possesses a single rare species of *Marmasoma*, not yet described. (*Fraudator perspicuus* Hutt., described as a Bombyliid, is an undoubted Empidid).

There are a number of subfamilies represented in Australia, of which the principal are the Anthracinae, Lomatiinae, Systropinae and Bombyliinae. The Anthracinae are very distinct in having the fork of *Rs* placed at or very close to the cross vein *r-m*; to this group belong *Anthrax*, *Argyramoeba*, *Cytherea*, *Exoprosopa* and *Hyperalonia*. The first two genera contain species of medium size, generally having the wing handsomely marked with black. *Hyperalonia bombyliformis* W.S.M. (pl. 25, fig. 21) is a fine species expanding over 40 mm. with the dark fuscous abdomen crossed by a wide band of pale yellowish hairs, and the brownish wings marked with eight or more dark spots. The Lomatiinae contains species with narrower, flattened abdomens and with R_4 and R_5 strongly looped; most of the species belong to *Oncodocera* and *Comptosia*. *C. fasciipennis* Macq. (pl. 25, fig. 22) is a common species with dark chocolate brown body with reddish lateral spots; the wings, expanding to 40 mm., are very dark and crossed by a pure white band near the apex. *C. sylvanus* Fabr. is a smaller species with the anterior half of the wings black. The Systropinae are forms with very slender abdomen, usually found visiting flowers. *Systropus clavifemoratus* Hardy (fig. W50) is not uncommon, and in appearance somewhat resembles a *Leptogaster*. The true Bee-flies are the stout-bodied Bombyliinae with long, slender proboscis, R_4 and R_5 not strongly looped as in Lomatiinae, and *Rs* forking well before *r-m*. Most of the species belong to *Systoechus* (fig. W55), *Sisyromyia* and *Bombylius*. *Systoechus platyurus* Walk. is a common, brownish species with a proboscis 7 mm. long, found all over Australia. *Sisyromyia aurata* Walk. is a handsome, variable species marked with bright yellow or red hair. *Bombylius pictipennis* Macq. is handsomely marked in velvety black with whitish hairs on sides of thorax and forming a band across the abdomen; the wings are heavily marked in black. *Geron australis* Macq. is a smaller, very common species with a rather narrow abdomen, dark fuscous with slightly clouded wings.

Superfamily IX. EMPIDOIDEA

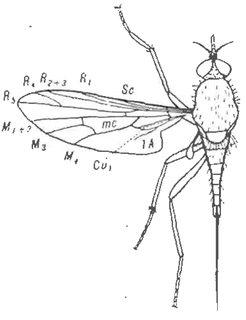


FIG. W56. *Hilara flavinceris* Miller. New Zealand. Fam. Empididae. Length 11 mm. [*A. Tonnoir del.*

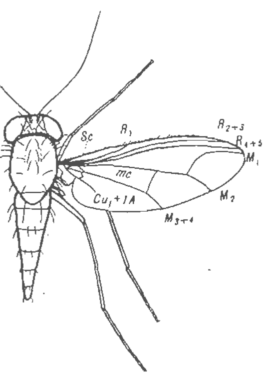


FIG. W57. *Psilopus fuscatus* Hutt., New Zealand. Fam. Dolichopodidae. Length of forewing 4 mm. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

The two families placed together here are easily distinguished as follows:—

Mostly metallic flies; proboscis fleshy, short, retracted; median cell elong-

ated (fig. W57), often incomplete basally through loss of basal piece of M_{3+4}, so that a long cell is formed from base to *im*; Cu_1 and *1A* absent or grealty reduced. Fam. 27. DOLICHOPODIDAE
Dull-coloured flies with proboscis usually rigid, projecting, and often long; venation very variable, median cell often present. Cu_1 and *1A* seldom absent or as greatly reduced as above. Fam. 26. EMPIDIDAE

Family 26. **Empididae** [Aus. 50, N.Z. 110]. A large family of predaceous flies of small to medium size; most of the species can be recognized by their long, piercing proboscis, small, rounded head with large eyes (often holoptic in the males), large thorax, convexly swollen above, slender legs and abdomen, and complicated genitalia of the males. There are, however, many exceptions to almost every character, and the venation in particular, though always reduced, is very variable; *Sc* is often absent (or fused with R_1); both *Rs* and *M* may have two or three branches; *mc* may be present or absent; Cu_1 either ends on *1A* at one-third or more from its tip, or turns backwards to meet *1A* much closer to base (fig. W56), or *1A* may be shortened or completely absent, leaving Cu_1 ending as a free branch in the membrane of the wing. The larvae are slender, cylindrical grubs found in decaying vegetable matter and also in streams and lakes; the flies are often seen circling swiftly and low down over water. The widespread genera *Empis*, *Hilara*, *Rhamphomyia*, *Hemerodromia* and *Drapetis* are found in both countries. *Hilara flavinceris* Miller (fig. W56) is an extraordinary species found on Lake Wakatipu, New Zealand, in which the side-pieces of the male are fused together to form a long, boat-shaped organ. The male of one species of *Rhamphomyia* from Tasmania has the same parts fused into a long slender process resembling an ovipositor. Some New Zealand species of *Hilara* have silvery vesicles on the sides of the abdomen; these can be inflated, enabling the insect to float slowly in the air. *Fraudator perspicuus* Hutt. is a fine species from New Zealand, originally described as a Bombyliid.

Family 27. **Dolichopodidae** [Aus. 20, N.Z. 45]. Mostly small, predatory flies of slender build, metallic green or bronze coloration (some blackish), with soft, fleshy proboscis, long, slender legs, and highly specialized venation. *Sc* is shortened and usually ends on R_1; *Rs* has two long branches only; *M* usually has two branches, the upper straight or curved upwards, sometimes with a short lower fork, the lower sometimes not reaching the margin; the median cell is elongated and often open basally, so that one long cell extends from base to *im*; Cu_1 and *1A* are greatly reduced or absent (fig. W57). The males often differ greatly from the females in ornamentation. The most abundant genus is *Psilopus* with M_{1+2} forked (subfamily Dolichopodinae); *Ps. fuscatus* Hutt. (fig. W57) is a common New Zealand species. The Hydrophorinae, with M_{1+2} simple, include most of the genera and species. *Hydrophorus* and *Diaphorus* are widespread genera found in both countries; *Arachnomyia* and *Liparomyia* are found only in Australia and Tasmania, *Ostenia* only in New Zealand.

Division *CYCLORRHAPHA*

The larva pupates within a hardened, generally oval or barrel-like *puparium* (fig. W64), formed of the old larval skin; the imago opens the puparium along a circular suture which separates off a small cap at the anterior end. The flies of this group always have the antennae 3-segmented, but the scape (seg. 1) may be much reduced or apparently absent; seg. 3 is simple, never annulated, usually large, and has a dorsal or terminal arista (seldom a terminal style). The wings always have *Rs* and *M* with only two branches each; cross-veins *r-m* and *im* are generally present, the latter often lengthened; median cell usually present as a large elongated cell.

The Cyclorrhapha are conveniently divided into three Superfamilies, the Syrphoidea (or Aschiza), the Muscoidea (Schizophora or Myiodaria) and the Hippoboscoidea (Pupipara); these may be distinguished as follows:—

1. Leathery or horny flies, parasitic on mammals or birds; often wingless or with reduced wings. Larvae born when about to pupate.* XII. HIPPOBOSCOIDEA
   Not such flies.* 2
2. Frontal lunule and ptilinum absent (see p. 357). Cu_1 usually meeting *1A* beyond half-way from base, often close to wing-margin (anal cell elongate); if anal cell is absent, then *C*, R_1 and *Rs* are all thickened and end up about half-way along anterior margin, *C* being bristly. X. SYRPHOIDEA

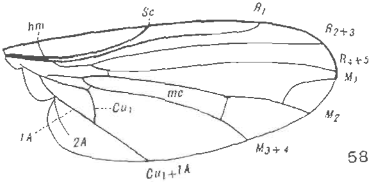
*The African tsetse-flies (genus *Glossina*), fam. Muscidae, also produce larvae about to pupate.

Frontal lunule and ptilinum present. Cu_1 meeting *1A* close to base or before half-way (except in Conopidae); or these veins may be vestigial or absent. XI. MUSCOIDEA

Superfamily X. SYRPHOIDEA

This group contains four families, distinguished as follows:—

1 A *vena spuria* (figs. W61, 63) present between *Rs* and *M*, crossing *r-m* longitudinally; an ambient vein formed by M_1 and *im* runs parallel to the distal margin from R_{4+5} down to M_{3+4}. Fam. 31 SYRPHIDAE
Vena spuria and ambient vein both absent; generally smaller flies than the above. 2



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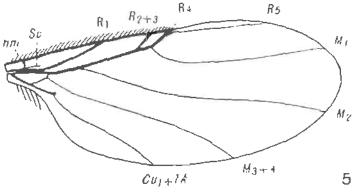

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FIG. W58. Wing of *Platypeza* sp. indet., Australia. Fam. Platypezidae.
FIG. W59. Wing of *Aphiochaeta omnivora* Huds., New Zealand. Fam. Phoridae. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

2. Head large, globular, formed chiefly by the two huge eyes; Cu_1 and *1A* meeting close to the margin of the wing. Fam. 30. PIPUNCULIDAE
Not such flies. 3

3. Venation abnormal. *C* thickened and usually very bristly, ending about half-way along anterior border; *Sc* and R_1 also thickened and shortened; no median cell or cross-veins present; junction of Cu_1 with *1A* lost; some species wingless. Fam. 29. PHORIDAE
Venation normal; median cell usually present; Cu_1 meeting *1A*, usually beyond half-way. Fam. 28. PLATYPEZIDAE

Family 28. **Platypezidae** [Aus. 5, N.Z. 0]. Four species of *Platypeza* (fig. W58) and one of *Ironomyia* occur in Australia and Tasmania. The introduced European "smoke-fly", *Microsania stigmaticalis* Zett. occurs in Tasmania and New Zealand, where it is found flying in countless numbers in smoke.

Family 29. **Phoridae** [Aus. 6, N.Z. 15]. This very aberrant family contains small, hunch-backed flies, sometimes wingless; the antennae have seg. 2 entirely hidden in an internal basal chamber of seg. 3. The genus *Aphiochaeta* occurs in both countries; *A. nebulosa* Walk. is common in Tasmania, *A. omnivora* Huds. (fig. W59) in New Zealand. *Conicera, Hypocera, Beckerina* and *Paraspiniphora* are other genera represented in New Zealand. The rare and very aberrant *Sciadocera rufomaculata* White (fig. W60) is found both in Australia and New Zealand. *Eutermiphora abdominalis* Lea is a wingless form found in ants'

ests in Victoria. *Braula caeca* Nitsch is a wingless bee-parasite introduced into ee-hives in Tasmania.

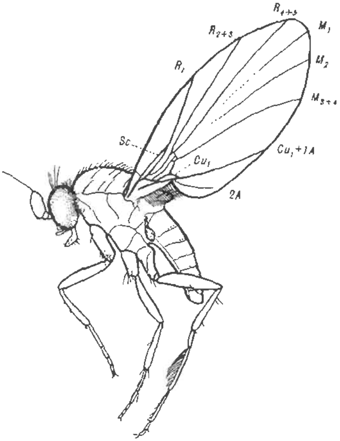

FIG. W60. *Sciadocera rufomaculata* White, male, Australia and New Zealand. Fam. Phoridae. Length of forewing 4 mm. Lettering as in fig. W8, p. 337.
[*A. Tonnoir del*

Family 30. Pipunculidae [Aus. 26, N.Z. 4]. Small flies with exceptionally large eyes; the larvae are parasitic on leaf- and plant-hoppers (Jassidae and Fulgoroidea), and hence the family is of economic importance. All the

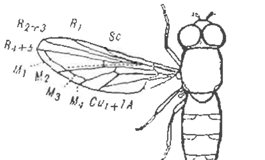

FIG. W61. *Syrphus novae-zelandiae* Macq., New Zealand. Fam. Syrphidae. Length 8 mm. The dotted vein is the *vena spuria*.
[*A. Tonnoir del.*

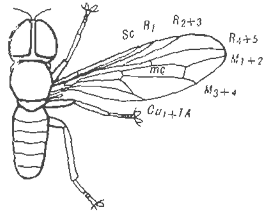

FIG. W62. *Pipunculus cruciator* Perk., Australia. Fam. Pipunculidae. Length 8 mm. Lettering as in fig. W8, p. 337 (after Perkins).

species belong to the genus *Pipunculus* (fig. W62); most of the Australian species were described by Perkins from specimens reared from Homopterous pests of sugar-cane.

Family 31. **Syrphidae** (Hover-flies) [Aus. 60, N.Z. 30]. This large family is distinguished by the presence of the *vena spuria* and ambient vein (figs. W61, 63). The flies are common objects, hovering motionless in the air, or darting suddenly sideways. Many are beneficial, their larvae being predaceous on aphids; others have larvae which feed on decaying vegetable matter in wet places. They are all handsome flies, some being prettily marked with yellow or orange, and some metallic. The great genus *Syrphus* contains somewhat slender flies whose larvae feed on aphis; *S. viridiceps* Macq. and *S. novae-zealandiae* Macq. (fig. W61) are two very common species, black with orange spots on abdomen, the former found in Australia, the latter in New Zealand. *Helophilus* is a fine genus exceptionally well represented in New Zealand: *H. trilineatus* Fabr. and the allied *H. antipodum* Sch. (pl. 2, fig. 27) are both common orange and black species. The allied *Pilinasica cingulata* Fabr. (pl. 25, fig. 23) is the largest and handsomest New Zealand species, black with creamy-white bands and spots. All these are found visiting flowers. *Milesia bilineata** Walk. (pl. 25, fig. 24) is another fine New Zealand species having two pale stripes on the thorax. *Orthoprosopa grisea* Walk. is a fine, blackish species found on Grass-trees (*Xanthorrhoea*) in Australia. The genus *Eristalis* has numerous species in Australia, of which the best known are perhaps *E. pulchellus* Macq. (pl. 20, fig. 26), *E. punctulatus* Macq. and the steel-blue *E. decorus* Macq. No native species of this genus occur in New Zealand, but the introduced Drone-fly, *E. tenax* L. is common in gardens in both countries. This and the two preceding genera have rat-tailed larvae which live in wet places, *E. tenax* in drains, the others mostly in accumulated moisture at the bases of the leaves of such plants as grass-trees, native flax, etc. The most peculiar genus of all is *Microdon*, whose extraordinary, hemispherical larvae and exactly similar puparia (fig. W64) are found in ants' nests, and were originally described as molluscs. *M. variegatum* Walk. (fig. W63) is a fine species with

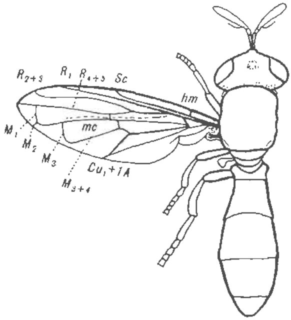

FIG. W63. *Microdon variegatum* Walk., Australia. Fam. Syrphidae. Length 10 mm. The dotted vein is the *vena spuria*. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

FIG. W64. Larva and puparium of same. Length 7 mm. [*A. Tonnoir del.*

large head and a distinct waist; it is black with small yellowish marks on abdomen, and partially darkened wings. Another peculiar genus found in Australia is *Ceriodes*, which mimics wasps; they have large heads and rather long, spoon-shaped antennae, and closely resembles the Eumenid wasps of the genus *Odynerus*.

Superfamily XI. MUSCOIDEA (MYIODARIA)

This group is distinguished by the presence of the frontal lunule (fig. W11, *frl*) and ptilinum. Their classification is one of the most perplexing problems in

*The generic position of this species is doubtful.

entomology, and cannot be said to have been solved as yet satisfactorily. They are usually separated into two principal Sections as follows:—

Squames small or absent. Section ACALYPTRATA

Squames large. Section CALYPTRATA

We must point out, however, that some Ortalidae, placed in the Acalyptrata, have squames quite as large as some Anthomyiidae, placed in the Calyptrata. The student must be prepared for exceptions, and must recognize that all Keys to this group are imperfect.

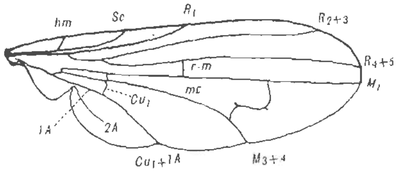

FIG. W65. Wing of *Limnia tranquilla* Hutt., New Zealand. Fam. Sciomyzidae. [A. Tonnoir *del.*

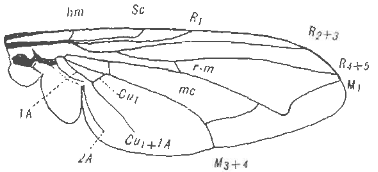

FIG. W66. Wing of *Anastellorhina stygia* Fabr., Australia and New Zealand. Fam. Muscidae. Lettering as in fig. W8, p. 337. [A. Tonnoir *del.*

Section ACALYPTRATA

It is in this Section that most confusion exists. As many as thirty families have been carved out of it, many of them on small characters which would be considered far below family value in other groups of Diptera, but which are made use of for lack of others. The following is an attempt to classify the twenty so-called "families" known to occur in Australia and New Zealand.

1. Wasp-like flies with swollen head and abdomen more or less bent: anal cell (between Cu_1 and $1A$) long. Fam. 32. CONOPIDAE
   Not such flies; anal cell always short or absent. 2
2. *Sc* complete, either separated from R_1 for its whole length, or, if very close to R_1, then ending quite separately on *C*. 3
   Sc incomplete, wholly or partially fused with R_1, never ending far apart from it on *C*, or absent. 12
3. Oral vibrissae present (see fig. W11, *v*). 4
   Oral vibrissae absent. 7
4. Cross-veins *r-m* and *im* close to one another, the latter three or four times its own length from the wing-margin. Fam. 33. HETERONEURIDAE
   Cross-veins *r-m* and *im* usually much farther apart, the latter always much nearer the wing-margin. 5
5. Proboscis horny. Fam. 34. SCATOPHAGIDAE
   Proboscis not horny. 6
6. Face strongly concave. Fam. 36. PHYCODROMIDAE
   Face not concave. Fam. 35. HELOMYZIDAE

7	Legs long, body very slender.	8
	Legs normal, body medium or stout.	9
8	R_{4+5} and M_1 converging distally.	Fam. 41. TANYPEZIDAE
	R_{4+5} and M_1 not converging distally.	Fam. 37 SEPSIDAE
9.	Antennae placed well above the middle of the head, often long, seg. 2 equal to or longer than seg. 3.	Fam. 38. SCIOMYZIDAE
	Antennae placed about the middle of the head, seg. 2 never longer than seg. 3.	10
10.	Series of fronto-orbital bristles complete (fig. W11, *or*, *for*), the lower or anterior ones always close to the eyes; wings mostly with ocellate colour-patterns.	Fam. 42. TRYPETIDAE
	Series of fronto-orbital bristles incomplete (lower or anterior ones absent).	11
11.	Middle tibiae with apical spurs.	Fam. 40. ORTALIDAE
	Middle tibiae without spurs.	Fam. 39. SAPROMYZIDAE
12	Hind tarsus with seg. 1 shorter than seg. 2 and usually conspicuously dilated.	Fam. 50. BORBORIDAE
	Hind tarsus normal, with seg. 1 always longer than seg. 2.	13
13.	Median cell incomplete basally (stem of M_{3+4} absent).	14
	Median cell complete basally (stem of M_{3+4} present).	16
14.	Anal cell small but complete.*	Fam. 50. DROSOPHILIDAE
	Anal cell absent or vestigial.	15
15.	Front bristly, face convex, mouth usually very large.	Fam. 48. EPHYDRIDAE
	Front smooth, face not convex, often retreating, mouth normal	Fam 47. CHLOROPIDAE
16	Front bristly only at top, near vertex.	17
	Front bristly at least as far as its middle.	18
17.	Oral vibrissae absent.	Fam. 43. PSILIDAE
	Oral vibrissae present (fig. W11, *v*)	Fam. 44. PIOPHILIDAE
18.	Postvertical bristles (fig. W11, *pv*) divergent	Fam. 46. AGROMYZIDAE
	Postvertical bristles convergent.	Fam. 45. GEOMYZIDAE

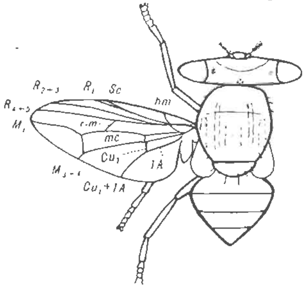

FIG. W67. *Achias amplividens* Walk., Australia. Fam. Ortalidae. Length 8 mm. [*A. Tonnoir del*

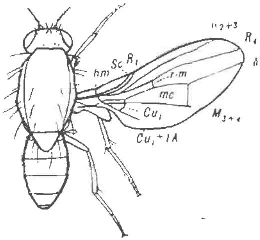

FIG. W68. *Huttonomyia scutellata* Hutt., New Zealand. Fam. Helomyzidae. Length 6 mm. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

Family 32. **Conopidae** (Wasp-flies) [Aus. 12, N.Z. 0]. Wasp-like flies not unlike the Syrphid genus *Cerioides* in appearance, but with a frontal lunule and without a *vena spuria*; the abdomen has a waist and the colouring is black or brown with yellow or orange markings. Twelve species of *Conops* are known from Australia, *C. pica* Macq. being the commonest.

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*Except *Asteia*, which has no anal cell.

Family 33. **Heteroneuridae** [Aus. 4, N.Z. 0]. A few undescribed species occur in Australia, but not in New Zealand. The position of cross-vein *im* close to *r-m* and far from the margin distinguishes this family from all other Acalyptrata.

Family 34. **Scatophagidae (Cordyluridae)** [Aus. 5, N.Z. 0]. Mostly rather large flies (8 to 12 mm. long) somewhat resembling Anthomyiidae, but with smaller squames. Four of the Australian species belong to *Tapeigaster* and one to *Scatophaga*. (*Cordylura debilis* Hutt., described from New Zealand, is an Anthomyiid.)

Family 35. **Helomyzidae** [Aus. 14, N.Z. 20]. Of the New Zealand species, *Huttonomyia* (fig. W68) contains 17, *Blepharoptera* (=*Leria*) two, while the single species of *Allophytopsis* is found in the Subantarctic Islands. *Huttonomyia* is also represented by nine species, and *Helomyza* by five, in Australia.

Family 36. **Phycodromiidae** (Kelp-flies) [Aus. 2, N.Z. 10]. Usually fairly large flies, found on kelp on sea-beaches, and particularly abundant in higher latitudes. Five species of *Coelopa* are known from New Zealand and the Subantarctic Islands; *C. littoralis* Hutt. is the commonest. One species of *Coelopa* and one of *Phycodromia* are known from Australia.

Family 37. **Sepsidae** [Aus. 6, N.Z. 0]. Four species of *Sepsis* and one each of the endemic genera *Xenosepsis* and *Australosepsis* have recently been described from Australia. *Sepsis plebeia* is the commonest species.

Family 38. **Sciomyzidae** [Aus. 20, N.Z. 20]. Fairly large flies, often with beautifully speckled wings; *Sciomyza* occurs in both countries, *Dichaetophora* in Australia. New Zealand possesses thirteen species of the fine genus *Limnia*, (fig. W65), very conspicuous by their spotted or ocellated wings; one of these, *L. obscura* Hutt., is shown in pl. 2, fig. 28. *Helosciomyza* contains five New Zealand and two or three Australian species. The Dryomyzinae, sometimes considered as a separate family, are represented by *Dryomyza* in Australia; *Polytochus spinicoxa* Lamb is found in the Subantarctic Islands and *Actora bipunctata* Hutt. in the Chatham Islands.

Family 39. **Sapromyzidae** [Aus. 41, N.Z. 16]. This family is divisible into two distinct subfamilies, considered as separate families by some authors. The Sapromyzinae (Lauxaniinae) have two pairs of fronto-orbital bristles and a pre-apical bristle on the tibiae. *Sapromyza* is the commonest genus, with 27 Australian and nine New Zealand species; of the latter, *S. dichromata* Walk. is very common everywhere. *Austrosapromyza* contains four New Zealand species with beautiful, spotted wings. Three New Zealand species of *Lauxania* occur, distinguished by small, white, longitudinal lines on their bodies. Australia possesses four monotypic genera, *Trigonometopus*, *Rhagodolira*, *Poecilohetaerus* and *Paranomina*. The Lonchaeinae have only one pair of fronto-orbital bristles and no pre-apical bristle on the tibiae. Five undescribed species in New Zealand belong to a new genus near *Palloptera*; they have vibrating wings with a black apical spot. *Lonchaea aurea* Macq. (=*L. splendida* Loew) is common in both countries; its larva lives in decaying tomatoes and potatoes.

Family 40. **Ortalidae** [Aus. 50, N.Z. 1]. Closely allied to the preceding family, but distinguished by the presence of spurs on middle tibiae. Mostly handsome flies of moderate size, often with metallic colouring and shaded or banded wings. The family is divided into a number of subfamilies, considered by some authors as distinct families; others include the Sapromyzidae and Tanypezidae within it. The only New Zealand species belongs to the genus *Herina*, which has seven species in Australia. The finest Australian species belong to the genera *Duomyia* and *Lamprogaster*; the latter contains thirteen species of very handsome flies with very much widened abdomens; *L. laeta* Guer. (pl. 20, fig. 27) and *L. flavipennis* Macq. are the best known. Both these genera belong to the Platystominae, the dominant subfamily in Australia, which possesses representatives of no less than eight other genera. *Euprosopia tenuicornis* Macq. (pl. 25, fig. 25) is a handsome fly with banded wings. *Toxura*, with three species, is peculiar to Australia. The genus *Achias*, found in Papua and North Queensland, has the eyes carried on lateral stalks like those of the Diopsidae; but, unlike these latter, the antennae are normal in position. *A. amplividens* Walk. (fig. W67) is the best known species. (True Diopsidae only occur in India and Africa).

Family 41. **Tanypezidae** [Aus. 7, N.Z. 0]. Very slender flies somewhat resembling ants, and often found walking about on twigs or on the ground. Of the Australian species, five belong to *Calobata* and two to *Nerius*; the former are indigenous species, but the latter (*N. inermis* Sch. and *N. lineolatus* Wied.) range

widely from the East Indies to Queensland, the larvae feeding in decaying banana stalks.

Family 42. **Trypetidae (Trypaneidae)** (Fruit-flies) [Aus. 32, N.Z. 4]. *This family consists of handsome flies, mostly with gaudily marked wings.* The larvae of some species make galls in twigs; others feed in ripening fruit, and are very serious pests to orchardists in Australia. The Queensland Fruit-fly,

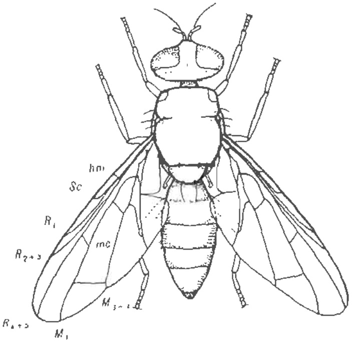

FIG. W69. *Chaetodacus tryoni* Frogg. (Queensland Fruit-fly). Fam. Trypetidae. Length 6.5 mm. Lettering as in fig. W8, p. 337.
[A. *Tonnoir* del.

Chaetodacus tryoni Frogg. is brown, marked with yellow, and with transparent wings. It has practically been responsible for the abandonment of commercial stone-fruit orchards in Queensland, and is spreading southwards in New South Wales. *Dacus psidii* Frogg. and *Rioxa musae* Frogg. are pests of guavas and bananas in Queensland. The Mediterranean Fruit-fly, *Ceratitis capitata* Walk. is somewhat smaller than *D. tryoni*, dark brown, with richly variegated wings. It was introduced into New South Wales and Western Australia more than twenty years ago, and has become one of the worst of all orchard pests, especially in oranges. Several handsome species of *Trypeta* and *Tephritis* are not uncommon in Australia. In New Zealand there are also four native species of *Tephritis*, which have been bred from galls of the terminal buds of species of *Cassinia* and *Veronica*. *Urellia*, *Urophora* and *Asciura* are represented by one or two species each in Australia.

Family 43. **Psilidae** [Aus. 2, N.Z. 0]. Undescribed species of *Loxocera* occur in Australia, but the family is absent from New Zealand.

Family 44. **Piophilidae**. No native species known in either country. The introduced cheese-skipper, which is the larva of *Piophila casei* L., is common in both countries. This genus differs from the Sepsidae, with which it was formerly placed, in the reduced form of *Sc*.

Family 45. **Geomyzidae (Opomyzidae)** [Aus. 6, N.Z. 12]. One species of *Opomyza* is known from Australia, together with several unplaced species. Of the New Zealand species, eight belong to *Diastata*, nearly all with spotted wings; *Anthomyza* and *Calopterella* are also represented there.

Family 46. **Agromyzidae** [Aus. 22, N.Z. 16]. The arista of the antennae is neither pectinate nor plumose, the costa is not incised, and the anal cell is present but very small. Most of the New Zealand species belong to *Agromyza*, and a single species of the same genus, *A. phascoli* Coq., damages beans in Australia. M. Watt has described very fully the interesting mines or galleries made by the larvae of these flies in the leaves of native Veronicas, ferns, etc. in New Zealand. Numerous undescribed leaf-mining species of *Phytomyza* exist in Australia. *Ph. affinis* Fall. and *Ph. albiceps* Meig. are common leaf-mining pests in gardens in both countries; they are of European origin. This genus and *Cera-*

tomysa occur in New Zealand, the latter containing two very common species. *Cryptochaetum* (=*Lestophonus*) contains two species whose larvae are parasitic on Coccidae.

Family 47. **Chloropidae (Oscinidae)** [Aus. 41, N.Z. 15]. The New Zealand species belong to *Chlorops, Oscinis* and *Oscinella*. All the above-named genera and several others occur in Australia, two being peculiar to it. *Batrachomyia nigritarsis* Sk. is a dark brown fly whose larva is parasitic beneath the skin of certain Australian frogs. Other Australian genera are *Parahippelates, Scoliophthalmus* and *Formosina*.

Family 48. **Ephydridae** [Aus. 10, N.Z. 15]. *Ephydra* and *Hydrellia* occur in both countries; *Ectropa* and *Nothiphila* in Australia; *Clasiopa, Ephygrobia, Hyadina, Parahyadina, Scabella, Gymnopa* and *Parydra* in New Zealand.

Family 49. **Drosophilidae** [Aus. 24, N.Z. 13]. Face vertical in profile, with oral vibrissae present; arista of antennae usually plumose or pectinate; anal cell present or absent. The Australian species belong to *Drosophila, Amiota, Leucophenga* and *Scaptomyza*; there are also six introduced species. New Zealand has 13 species, eleven of which belong to *Drosophila* and two to the peculiar genus *Asteia*, which has *im* and anal cell absent.

Family 50. **Borboridae** [Aus. 6, N.Z. 12]. Small black or brown flies distinguished by the form of the hind tarsi, which have seg. 1 shortened and swollen. The New Zealand species mostly belong to *Limosina*, with reduced venation and no anal cell; other genera represented are *Borborus*, with median and anal cells complete, and the wingless *Apterina*. The family is not uncommon in Australia, but none of the species have so far been described.

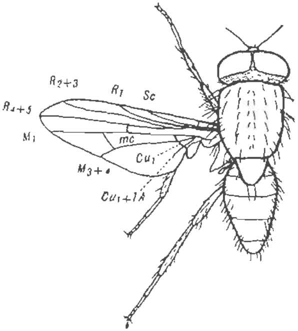

Fig. W70. *Ophyra chalcogaster* Wied., Australia. Fam. Anthomyiidae. Length 6 mm. Lettering as in fig. W8, p. 337. [*A. Tonnoir del.*

Section CALYPTRATA

As in the Acalyptrata, so in this section, certain characters have been used, for division into families, which are of little real value. The most unsatisfactory of these is the condition of the arista of the antennae, whether bare, or partially or wholly plumose. This was used to separate the old families Sarcophagidae (arista plumose from base to middle), and Dexiidae (arista pubescent), from the Muscidae (arista plumose to end), on the one hand, and from the Tachinidae (arista bare), on the other. Some Tachinidae, however, have a pubescent arista, and there is certainly no way of separating the Dexiidae satisfactorily as a distinct family from the Tachinidae. The Sarcophagidae also are true Tachinids morphologically. These groups are here reduced to the rank of subfamilies within the Tachinidae. One of the most constant and reliable characters to be found is the presence or absence of ***hypopleural bristles*** (fig. W12); these occur

in all Tachinids (sens. lat.) and also in the Blow-flies (Calliphorinae), which some authors would also include in the Tachinidae on that account, though they would appear to be otherwise true Muscidae. Another useful character is the

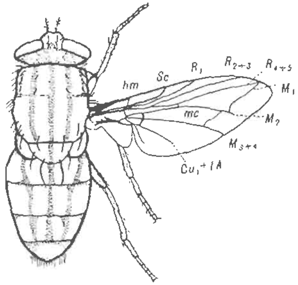

FIG. W71. *Sarcophaga tryoni* J. & T., Australia. Fam. Tachinidae, subfam. Sarcophaginae. Length 11 mm. Lettering as in fig. W8, p. 337. [A. *Tonnoir del.*

biconvex swelling beneath the scutellum*, which occurs in Tachinidae (*sens. str.*) and Dexiidae, but is absent in Sarcophagidae and Blow-flies. The four families here recognized may be separated as follows:—

1. Proboscis present. 2
   Proboscis absent. Fam. 54. OESTRIDAE
2. M_1 continues straight on beyond *im*. Fam. 51 ANTHOMYIIDAE
   M_1 turns up sharply beyond *im*, either meeting or closely approaching R_{4+5} 3
3. Abdomen without dorsal or apical bristles; antennal arista plumose right to end; hypopleural bristles absent (Muscinae) or present (Calliphorinae). Fam. 52. MUSCIDAE
   Abdomen with dorsal and apical bristles (except in Phasinae); antennal arista never plumose to end, often bare or only pubescent; hypopleural bristles always present. Fam. 53. TACHINIDAE

Family 51. **Anthomyiidae** [Aus. 50, N.Z. 60]. This family is closely related to the Scatophagidae, but the squames are larger; it is also closely related to the Muscidae, through forms like *Muscina*, in which M_1 is only slightly turned up distally. A striking group of genera are the predatory flies, called "cannibal flies" in New Zealand, which are found resting on rocks in or near running streams, and which fly up and seize other insects, (especially Mayflies) and suck them dry; these belong to the genus *Trichophthicus*, and are also found in Tasmania. They have strong, hooked teeth on the labellum, and many are rather handsomely marked in black and grey. *Exul singularis* Hutt. (pl. 2, fig. 29) with similar habits, is a very rare and extraordinary fly found only in a few mountainous localities in the South Island of New Zealand; the wings are of great breadth and well rounded, and are shaded black. Species of *Lispa* and *Xenolispa* frequent the margins of rivers and water-holes in Australia and also occur along the sea-shore. *Limnophora* and *Coenosia* have representatives in both countries; *Anthomyia*, *Helina* and *Ophyra* contain a number of Australian species. *Ophyra chalcogaster* Wied. (fig. W70) and *Australophyra analis* Macq. swarm around carrion and dead sheep in Australia, and their larvae are also found in the wool of "blown" sheep; the former is quite black, the latter has a much broader abdomen of a deep metallic blue colour. *Pygophora* and *Macrochaeta* are two small genera peculiar to Australia. The "Lesser House-fly", *Fannia canicularis* L., is a common introduced species in both countries.

*This swelling also occurs in some Acalyptrata, e.g. *Leucophenga* (fam. Drosophilidae).

Family 52. **Muscidae** *(House-flies, Blow-flies)* [Aus. 60, N.Z. 8]. The subfamily Muscinae has no native species in New Zealand. In Australia a number of native species of *Musca* are known, the commonest being *M. vetustissima* Walk. (probably =*M. pumila* Macq.), which is a great annoyance in the bush, settling on people's backs in hundreds, and buzzing into their faces. The common House-fly, *M. domestica* L., is abundant throughout both countries, having been introduced early in colonization; it is both a nuisance and a serious menace to health, carrying filth everywhere, and being partially responsible for the spread of typhoid fever, infantile diarrhoea and even tuberculosis. Its larvae live in decomposing vegetable matter, horse manure and refuse heaps. *Muscina stabulans* Meig. is another introduced species of similar appearance; it does not enter houses so much, but is more attracted to food. The Stable-fly, *Stomoxys calcitrans* Fabr., is an introduced species somewhat larger than a house-fly; it frequents stables and mangers, and has a rigid, projecting proboscis with which it bites horses, cattle and man viciously. This fly is a known carrier of anthrax. The Hornfly or Buffalo-fly, *Lyperosia exigua* Meij., is an allied species introduced into the Northern Territory and the Kimberley district of N-W. Australia; it causes large, open sores on cattle and buffalo.

The subfamily Calliphorinae comprises the Blow-flies, Blue-bottles and Green-bottles; they differ from the Muscinae in their generally larger size and in having hypopleural bristles. They are serious pests, laying their eggs freely on meat, wool, blankets, etc.; in summer many of the species lay young maggots and their rate of propagation is enormous. The synonymy of the commoner species is very complicated, and the distinctions between the so-called "genera" into which the original *Calliphora* R-D. is now divided are very slight. The commonest Blow-flies in New Zealand are *C. quadrimaculata* Swed., a large species with two spots on each wing and a dark metallic bluish abdomen; *C. auronotata* Macq. of smaller size; the introduced European Blue-bottle, *C. erythrocephala* Meig. very similar in appearance to the first-named; the introduced European Green-bottle, *Lucilia caesar* L.; and the Australian Golden-haired Blow-fly, *Anastellorhina* (*Neopollenia*) *stygia* Fabr. (=*C. villosa* R-D) (pl. 25, fig. 26). This latter species is the commonest Blow-fly in Australia, swarming both in houses and in the bush; the Australian Blue-striped Blow-fly, *A. augur* Fabr. (=*C. oceaniae* R-D) is also quite common; it is somewhat smaller, and has a dull yellow patch on each side of the abdomen. *Lucilia sericata* Meig. is the common introduced Green-bottle in Australia; *L. caesar* L. is also stated to be a common introduced species, but does not occur around Sydney.

Certain Blow-flies have formed the habit of attacking sheep, laying their eggs or maggots on the soiled wool of the crutch of the female, or around the shoulders. The larvae set up a fevered condition, and a bacterial invasion of the infested part soon follows, often with maggots of other species, such as *Ophyra* (Anthomyiidae) added also. The larvae often puncture the skin and travel along the sides and back of the sheep, causing the horrible infestation called "maggoty" sheep. The annual losses from this one disease are as great as those from all natural causes combined, and are computed at about one million pounds sterling at the present time for Queensland, and twice that amount for New South Wales. The disease also exists in northern New Zealand, but not to the same extent. The chief culprit is said to be the Blow-fly *Pycnosoma rufifacies* Macq. (=*Chrysomyia albiceps* Wied); it has a blue body, silvery face and red eyes, and ranges as far as India. Its larva has rings of processes on the body, and is called the "hairy sheep-maggot". It completes its life-cycle in from nine to fourteen days in summer, and is especially active after rains. *Lucilia sericata* Meig. in Australia, and *L. caesar* L. in New Zealand are also stated to attack sheep in this manner. Good work has been done on this problem under the Blow-fly Commission, but no really cheap and always effective remedy has yet been found. The chief remedies are the poisoning of the carcases of dead sheep with arsenic, baiting fly-traps with the same, and the introduction and rearing in large numbers of Chalcid parasites of the larval and pupal stages of the flies; of these latter *Mormoniella* (*Nasonia*) *brevicornis* Ashm. (p. 277) has already been tried, but so far with little success.

Family 53. **Tachinidae** [Aus. 220, N.Z. 200]. This is a very large family containing flies whose larvae are mostly parasitic within the larvae of other insects, especially Lepidopterous caterpillars, and also within the bodies of Orthopteroid insects. The family is divided into four subfamilies.

The Sarcophaginae or Flesh-flies (sometimes called Scavenger-flies) are known by having the antennal arista plumose from base to middle; they are all

marked with stripes on the thorax, usually in pale grey. They infest slaughter-houses and pig-sties, and are also found in the bush. There are about 25 Australian species, the commonest being *Sarcophaga aurifrons* Macq., with red eyes and golden front of the head. *S. tryoni* J. & T. (fig. W71) is very common in S. Queensland. *Locustivora pachytyli* Sk. is a useful species whose larva parasitizes the Plague-Locusts of the genus *Chortoicetes*. Several species of *Sarcophaga* occur in New Zealand, the commonest being *S. milleri* J. & T.

The Dexiinae are a very handsome group with the arista pubescent, the legs long, and the face usually elongated under the eyes. They are all beneficial, the larvae parasitizing those of other insects, especially Coleoptera. About 90 Australian species are known, but they are entirely absent from New Zealand. Many fine species occur, measuring up to 18 mm. long and broad in proportion. The most abundant genus is *Rutilia*. *R. splendida* Don. is an exceedingly handsome species with metallic blue and green colouring, and dark patches near the bases of the wings; this and the duller and larger *R. inornata* Guer. and *R. vivipara* Fabr. are commonly met with hovering motionless in the air in sunshine, or resting on the sunny side of tree-trunks. *R. decora* Guer. and *R. formosa* R-D. are two very large and handsome metallic species with similar habits. The allied genera *Amphibolia* and *Euamphibolia* contain some handsome species, of which *A. valentina* Macq. and *E. fulvipes* Guer. (pl. 25, fig. 27) are the best known; they have the abdomen marked intricately in black and creamy-white. The large *Chaetogaster violacea* Macq. (pl. 25, fig. 28) and the smaller *Microtropesa sinuata* Don. have the wings orange basally and fuscous distally. *Amoenia leonina* Don. (pl. 25, fig. 29) is a very handsome fly having the abdomen rich metallic green and blue, with white lateral spots, and the face rich golden-yellow; it is often found resting on roads and paths. *Rhynchiodexia longipes* Macq. (pl. 20, fig. 29) known as the "Long-legged Fly", is a very graceful, grey species common on sunny tree-trunks.

The Phasinae are a group of Tachinidae in which the abdomen is bare of bristles, and is either globular or quite flat and rounded. Little is known of the Australian species. *Phania verecunda* Hutt. (pl. 2, fig. 30) is a pretty New Zealand species with orange abdomen, found sitting about on grass-stems. The genus *Campbellia* contains two very rare New Zealand species with very broad wings.

The Tachininae are very bristly flies with the arista bare or only pubescent; they include about 90 Australian species and all but a few of the New Zealand forms. They are all beneficial forms, mostly parasitic on caterpillars. Numerous species of *Macquartia* and *Phorocera* occur in both countries; other genera found in New Zealand are *Calcager*, *Nemoraea*, *Procissio*, *Occisor*, *Peremptor* and *Hystricia*. *Hystricia pachyprocta* Now. (pl. 2, fig. 31) is the finest of all New Zealand Tachinidae; it is a large and very bristly fly of a rich brown colour, often abundant on hedges or along water-courses. *Ocypteropsis flavifrons* Macq. is a peculiar, rather slender, Australian species, 9 mm. long, with reddish-brown abdomen tipped with black. *Heterometopia argentea* Macq., found in Tasmania and on Mt. Kosciusko, has the male black with a silver sheen above, in such a way that the insect is conspicuous when advancing in the air but suddenly seems to disappear as it turns. *Schizotachina fergusoni* Bez. (fig. W1, G) is an Australian representative of the little known group called "fissicorn Tachinids", in which seg. 3 of the antennae is divided into two or more elongate lobes separated by deep clefts.

An attempt is being made to introduce the European Tachinids *Digonochaeta setipennis* Fall. and *Racodineura antiqua* Meig. into New Zealand under scientific control with a view to checking the ravages of the European Earwig (*Forficula auricularia* L.), which now swarms in countless numbers throughout Otago and other districts, and is a serious pest of flowers, vegetables and stone-fruit. *D. setipennis* deposits living larvae which attack the earwigs and bore into them. *R. antiqua* lays small, hard eggs on the earwigs' food; when swallowed, the young larva hatches out and devours its host.

Family 54. **Oestridae** (Bot-flies) [Aus. 1, N.Z. 0]. These flies have no proboscis; the larvae are internal parasites on mammals. The only native species is the Australian *Tracheomyia macropi* Frogg., known, however, only from its larva, which infests the tracheae of kangaroos. There are three introduced species:—*Gastrophilus intestinalis* de Geer (=*G. equi* Clark), the European Bot-fly; the allied *G. veterinus* Clark (=*G. nasalis* L.), also from Europe; and the Sheep Nostril Fly, *Oestrus ovis* L.* The Bot-fly lays its eggs on the hairs of the

*The Camel Bot-fly, *Cephalopsis titillator* Clark, has not yet been recorded as introduced into Australia, but probably occurs amongst camels there.

shoulders of the horse, whence they are licked and swallowed by the animal; the larvae hatch out and attach themselves to the lining of the stomach, finally passing out with the faeces when full-fed and pupating in the ground. The Sheep Nostril Fly lays living maggots in the nostrils of the sheep, whence the larvae pass up into the nasal sinuses, causing great suffering to the animal; when full-fed, they are sneezed out by the sheep, and pupate in the ground.

Superfamily XII. HIPPOBOSCOIDEA (PUPIPARA)

This Section includes three very highly specialized families in which the flies are themselves parasitic on mammals or birds and the larvae live within the body

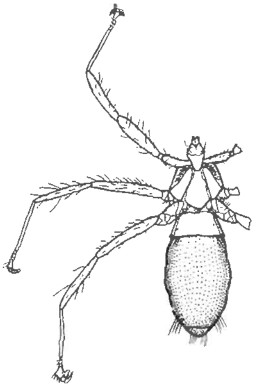

FIG. W72. *Cyclopodia pteropus* Rainb., Australia. Fam. Nycteribiidae. Length 5 mm.

of the female fly until ready to pupate, when they are ejected and pupate attached to the skin of the host. The following Key will distinguish the three families:—

1. Spider-like, wingless flies, with the small head folded flatly back upon the thorax; tarsi with seg. 1 very long.
   Fam. 57. NYCTERIBIIDAE
   Not such flies. 2
2. Hind coxae enlarged; claws of tarsi simple; wings, when present, pubescent, with veins equally stout and arranged evenly on the wing-membrane. Fam. 56. STREBLIDAE
   Hind coxae not enlarged; claws of the tarsi toothed; wings, when present, with the veins mostly crowded up anteriorly, and with weaker veins placed wider apart obliquely across the wing.
   Fam. 55. HIPPOBOSCIDAE

Family 55. **Hippoboscidae** (Louse-flies) [Aus. 5, N.Z. 1]. A few native species are known in Australia, parasitic on Marsupials and birds. The Wallaby Louse-fly, *Ortholfersia macleayi* Leach, is found commonly on marsupials; it is an ugly, winged fly about 10 mm. long, with brown body and a greenish tinge on legs; it has five longitudinal veins crowded close up towards the costa, and the rest of the membrane is obsolescent. *Ornithoctona nigricans* Leach is a fine fly taken on a white owl in Queensland. *Ornithomyia perfusa* Speiser was found on an owl in Queensland, *O. stipituri* Sch. on the emu wren, and *O. australasiae* Leach (fig. W73) on the Laughing Jackass and the Goshawk. Only one species of *Ornithomyia* is known from New Zealand, but it is certain that many birds in both countries have these flies on them, if they were carefully searched for.

The European Sheep-Ked, *Melophagus ovinus* L., commonly called the Sheep-tick, is common in both countries. It is a wingless, dark brown, blood-sucking insect, rather spider-like in appearance, and with very strong claws, it does considerable damage at times amongst lambs.

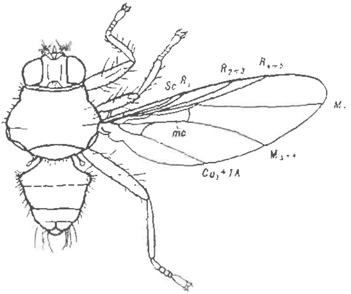

FIG. W73. *Ornithomyia australasiae* Leach, Australia. Fam. Hippoboscidae. Length 6 mm.

Family 56. **Streblidae** [Aus. 1, N.Z. 0]. These are parasitic on bats. An undescribed species has been taken by Dr. Illingworth in N. Queensland.

Family 57. **Nycteribiidae** (Bat-flies, Spider-flies) [Aus. 5, N.Z. 0]. These extraordinary, spider-like flies are parasitic on bats, where they may be found running swiftly about in the fur, and are difficult to catch. Several species of *Nycteribia* have been found on Australian bats, and a much larger species, *Cyclopodia pteropus* Rainb. (fig. W72) is found on flying-foxes.

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CHAPTER XXVI

Order SIPHONAPTERA

(or APHANIPTERA)

(Fleas)

THE Fleas form a very distinct Order of Insects, highly specialized by their parasitic habits, laterally flattened body, piercing and sucking mouth-parts, great powers of leaping and entire loss of wings. Morphologically they appear to be most closely related to the Mecoptera and Diptera, but their actual origin is uncertain.

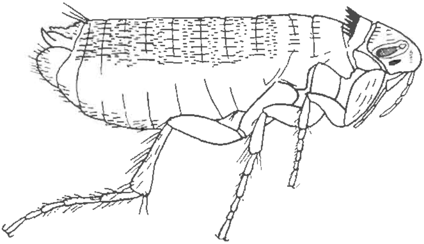

FIG. X1. *Pygiopsylla hoplia* J. & R., Australia. Fam. Pulicidae. Length 2 mm.
[*A. Tonnoir del.*

Characters. Wingless, parasitic insects possessing great powers of leaping, and with the whole body very strongly flattened laterally; the food consists only of the blood of mammals or birds.

H e a d (fig. X2) small, closely attached to the thorax, without any neck constriction; strongly arched above, the mouth-parts hypognathous. Special organs known as *combs,* and formed of rows of deeply pigmented spines or *ctenidia,* (fig. X5), are generally present, especially on the edge of the cheeks (*genal combs*). *Antennae* (fig. X2, *ant*) short, hidden when at rest in the *antennal groove,* placed above and behind the eye; each antenna consists of a slender basal segment or stalk, a short, ring-like, second segment and a large club formed of a varying number of distal segments, which are often more or less fused together. *Compound eyes* (*e*) either with only a single lens, or absent. *Mouth-parts*:—The piercing and sucking apparatus is formed of the *labrum-epipharynx* (*lep*) and the two *mandibles* (*md*), all three about equally long; the former consists of a long, slender, hollow

style, armed with tubercles distally, and grooved ventrally to form the open food-channel, which is closed from below by the mandibles; these latter are elongated, flattened, cutting blades with serrated edges, and

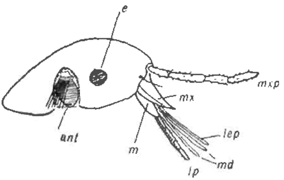

FIG. X2. Head and mouth-parts of the Human Flea, *Pulex irritans* L. *ant*, antenna; *e*, eye; *lep*, labrum-epipharynx; *lp*, labial palp; *m*, mentum; *md*, mandible; *mx*, maxilla; *mxp*, maxillary palp. [*A. Tonnoir del.*

grooved low down on the inner side; when the two mandibles are in apposition, the two grooves form the salivary channel, which is continued backwards to the opening of the salivary duct in the small and inconspicuous *hypopharynx*. *Maxillae* (*mx*) formed of a strong basal piece, usually triangular in shape, and a projecting, four-segmented palp (*mxp*), situated somewhat in the position of the antenna in many insects, and easily mistaken for it. *Labium* consisting of a strong basal piece, the *mentum* (*m*), and a pair of elongated *palpi* (*lp*), normally four-segmented, but sometimes secondarily divided into a considerable number of annuli; these are flattened and concave interiorly, and together form a sheath for the labrum and mandibles. The wound is made solely by the mandibles, which also carry the saliva to it; the blood is sucked back along the food-channel; the labium takes no part in feeding, being bent back on either side during that operation.

Thorax with the three segments short, increasing in vertical depth from before backwards. *Prothorax* sometimes armed posteriorly with a *prothoracic comb* (figs. X1, X5) formed of large ctenidia; *prosternum* large, extending forwards under the head, and having the forelegs articulated anteriorly with it, so that they appear to arise below the head. *Metathorax* with a large *epimeron* extending laterally below the first abdominal tergite, and developed in correlation with the great leaping powers of the hind legs. *Legs* large, the coxae very large and broad, trochanters small, femora stout, flattened; tibiae slender, about as long as femora; tarsi long, five-segmented, carrying two terminal claws and a small basad pad. *Wings* entirely absent.

Abdomen short and very deep, composed of ten distinct segments, of which the last three are highly specialized for sexual purposes; segs. 8 and 10 much reduced; seg. 9 bears a dorsal sensory organ called the pygidium, and also in the males, a pair of claspers and a manubrium. *Spiracles* ten pairs, three thoracic and seven abdominal, the latter on segs. 2-8.

Life History. The *eggs* are round or oval and are laid freely, not attached to the body of the host, and often dropped on to the ground. The larva (fig. X3) is an elongate, cylindrical grub, with well developed head, and without any legs, resembling that of the

Mycetophilid Diptera. It feeds on dust or refuse, or on the accumulations of dirt in birds' nests; when full-fed, it spins a small cocoon, within which it changes to a *pupa libera*. Both larval and pupal stages are passed through in a comparatively short time.

Distribution. The Order is represented by 33 native and 7 introduced species in Australia. In New Zealand, where native mam-

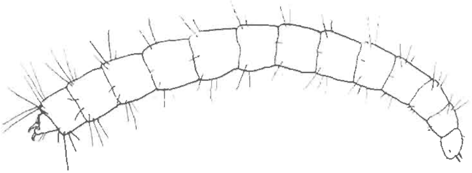

Fig. X3. Larva of the Cat Flea, *Ctenocephalus felis* Bouché. Length 4 mm. [*A. Tonnoir del.*

mals are practically absent, six species have been introduced; but the only known native fleas are *Parapsyllus australiacus* Roths. and an undescribed species found on the Pekapeka or Long-tailed Bat (*Chalinolobus morio*). A single species has been found on a parrakeet native to Antipodes Is.

Economics. Fleas are harmful to man and his domestic animals and birds, not only because of the irritation caused by their bites, but also because, in certain cases, they carry diseases. The chigoe, *Dermatophilus penetrans* L. a native of S. America, but now also found in Africa, attacks people by burrowing into the skin, especially under the toe-nails, where the female swells up to the size of a small pea, and causes intense suffering. A related species, the Stick-tight Flea, *Echidnophaga gallinacea* Wwd., attacks fowls and is becoming a serious pest in Western Australia. The Human Flea, the Cat Flea and the Dog Flea are commonly found in and around houses; all three bite man. The Indian Rat Flea, (*Xenopsylla cheopsis* Roths.) is the carrier of the dread disease Bubonic Plague (*Bacillus pestis*); this flea occurs on rats in all the warmer parts of Australia. The European Rat Flea and the Mouse Flea are common in the southern parts of Australia. All the above, except *X. cheopsis* and *E. gallinacea*, occur also in New Zealand. The Fowl Flea is recorded from New Zealand.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order SIPHONAPTERA 33 (2)

1. Dermatophilidae 4 (0)
2. Pulicidae 27 (1)
3. Ceratopsyllidae 2 (1)

The Order is divisible into three very distinct families, as follows:—

1. The three thoracic segments together shorter than first abdominal segment dorsally; epimeron of metathorax extending back beyond first

abdominal segment; maxillary palpi longer than fore coxae. Fleas permanently attached to the bodies of their hosts. (Chigoes).
Fam. 1. DERMATOPHILIDAE

The three thoracic segments together longer than first abdominal segment dorsally; epimeron of metathorax extending back only to level of end of first abdominal segment; maxillary palpi shorter than fore coxae. Fleas roaming freely on their hosts. 2

2. Maxillae triangular, with apex acute; species not parasitic on bats.
Fam. 2. PULICIDAE

Maxillae clubbed or dumb-bell shaped; species parasitic only on bats.
Fam. 3. CERATOPSYLLIDAE

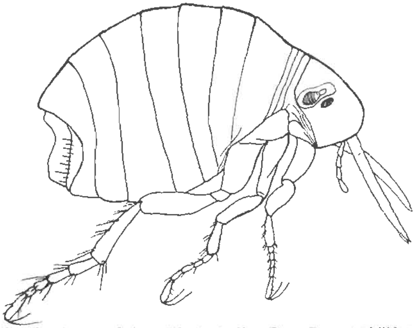

FIG. X4. *Echidnophaga ambulans* Oll., Australia. Fam. Dermatophilidae. Length 1.2 mm. [*A. Tonnoir del.*

Family 1. **Dermatophilidae (Sarcopsyllidae)** (Chigoes) [Aus. 4, N.Z. 3]. This family is represented in Australia by four native and one introduced species of the genus *Echidnophaga*. *E. ambulans* Oll. (fig. X4) is found on the Native Porcupine or Echidna, also on various marsupials, and has even been found attached to the Brown Snake. Three species are known from Western Australia, *E. liopus* R. & J. on the Echidna, *E. macronychia* R. & J. on *Bettongia*, and *E. myrmecobii* Roths. on a number of different marsupials. The introduced species is *E. gallinacea* Wwd., the Stick-tight flea of fowls.

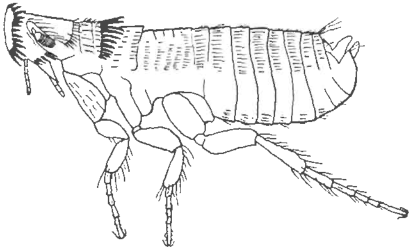

FIG. X5. *Stephanocircus dasyuri* Sk., Australia. Fam. Pulicidae. Length 1.8 mm. [*A. Tonnoir del.*

Family 2. **Pulicidae** (Fleas) [Aus. 27, N.Z. 1]. This family contains a large number of genera parasitic on mammals other than bats, and also on birds. The Australian species belong to twelve genera. *Macropsylla hercules* Roths. is a very large flea (5 mm. long), found on native water-rats. *Bradypsylla echidnae* Denny is another large species (4.5 mm. long), found on marsupials and Echidna. *Pygiopsylla* contains nine species found on terrestrial marsupials and rodents; one species has also been found on *Ornithorhynchus*. *P. hoplia* J. & R. (fig. X1) is found on Native Cats (*Dasyurus*). *Choristopsylla* contains three species found only on Opossums, and *Acanthopsylla* four species on various marsupials. Five species of the curious genus *Stephanocircus* are known, distinguished by the ctenidia on the crown of the head; the commonest is *S. dasyuri* Sk. (fig. X5), found in the pouch of the Native Cat and on the Bandicoot. *Parapsyllus australiacus* Roths. occurs on the Little Penguin (*Eudyptula minor*) and is therefore a native of Australia and New Zealand. Other genera represented are *Lycopsylla*, *Stephanopsylla* and *Uropsylla*. *Goniopsyllus kerguelensis* Tasch. is recorded from the Antipodes Is. Parakeet (*Pltaycerus unicolor*). There are six introduced species, viz., the Human Flea, *Pulex irritans* L., the Indian Rat Flea, *Xenopsylla cheopis* Roths., the European Rat Flea, *Ceratophyllus fasciatus* Bosc, the Mouse Flea, *Ctenopsylla musculi* Duges, the Cat Flea *Ctenocephalus felis* Bouché, and the Dog Flea *Ct. canis* Curtis; most of these are also found in New Zealand, where also the Fowl Flea, *Ceratophyllus gallinae* Schrk. is recorded as occurring.

Family 3. **Ceratopsyllidae** (Bat Fleas) [Aus. 2, N.Z. 1]. These fleas are remarkable for the dumb-bell shaped maxillae, and for the presence of ctenidia on the prothorax and abdomen. The Australian species are *Ceratopsylla caminae* Roths. and *C. reducta* Roths. An undescribed species has also been found in New Zealand.

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CHAPTER XXVII

Order TRICHOPTERA

(Caddis-flies)

The Caddis-flies form a well-defined Order closely related to the Lepidoptera. They are active, four-winged insects, somewhat resembling small moths, and carrying their wings folded roof-wise

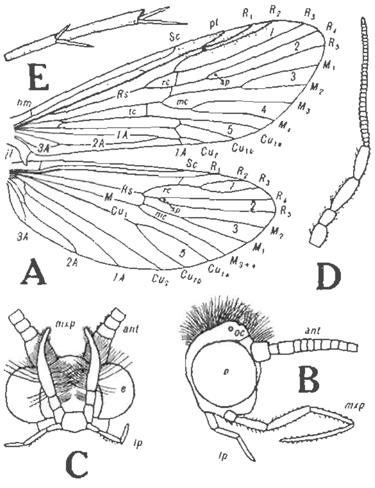


FIG. Y1. A. Wing-Venation of *Hydrobiosis umbripennis* McL., fam. Rhyacophilidae. Lettering as in fig. A8, p. 22; except *hm*, humeral veinlet; *jl*, jugal lobe; *mc*, median cell (open); *pt*, pterostigma; *rc*, radial cell (closed in *fw*); *sp*, wing-spot; *tc*, thyridial cell (closed in *fw*); *1*, *2*, *3*, *4*, *5*, the five apical forks; B, side view of head of same, showing *ant*, antennae (basal segments only); *e*, compound eye; *lp*, labial palpi; *mxp*, maxillary palpi; oc, ocelli; C, front view of head of *Zelandopsyche ingens* Till., male, New Zealand, fam. Sericostomatidae. Lettering as in B. D, maxillary palp of *Smicridea* sp. Australia, fam. Hydropsychidae. Note the secondarily annulated and much elongated fifth segment; E, hind tibia of same, showing middle and apical pairs of spurs. [*R. J. T. del.*

Plate 26

MECOPTERA AND TRICHOPTERA

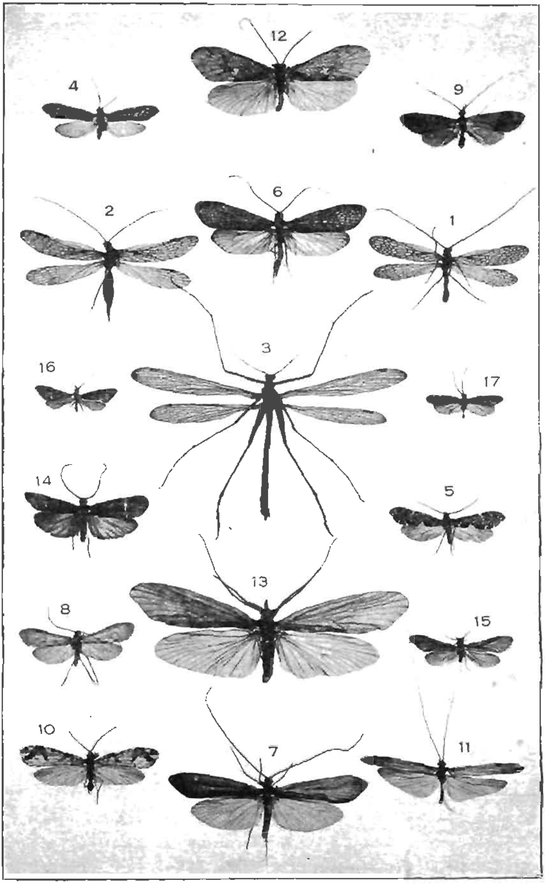
All figures natural size

Order MECOPTERA

1. *Chorista australis* Klug (Fam. Choristidae), male, Aus.
2. *Chorista australis* Klug (Fam. Choristidae), female, Aus.
3. *Harpobittacus tillyardi* E.P. (Fam. Bittacidae), male, Aus.

Order TRICHOPTERA

4. *Hydrobiosis umbripennis* McL. (Fam. Rhyacophilidae), male, N.Z.
5. *Polyplectropus puerilis* McL. (Fam. Polycentropodidae), male, Aus. and N.Z.
6. *Stenopsychodes montana* Till. (Fam. Polycentropodidae), female, Aus.
7. *Stenopsychodes hiemalis* Till. (Fam. Polycentropodidae), female, Aus.
8. *Hydropsyche colonica* McL. (Fam. Hydropsychidae), male, N.Z.
9. *Anisocentropus latifascia* Walk. (Fam. Calamoceratidae), male, Aus.
10. *Philorheithrus agilis* Huds. (Fam. Calamoceratidae), male, N.Z.
11. *Triplectides amabilis* McL. (Fam. Leptoceridae), male, N.Z.
12. *Oeconesus maori* McL. (Fam. Sericostomatidae), male, N.Z.
13. *Zelandopsyche ingens* Till. (Fam. Sericostomatidae), female, N.Z.
14. *Plectrotarsus gravenhorsti* Kol. (Fam. Sericostomatidae), male, Aus.
15. *Pycnocentria evecta* McL. (Fam. Sericostomatidae), male, N.Z.
16. *Pycnocentria funerea* McL. (Fam. Sericostomatidae), male, N.Z.
17. Gen. et sp. indet., Cradle Mountain, Tasmania, 3200 ft.



W. C. Davies photo.

MECOPTERA AND TRICHOPTERA

over the body. They are found only in the neighbourhood of water, and are almost all either crepuscular or nocturnal, though they can frequently be captured during the day by beating or sweeping the foliage along the margins of rivers or ponds. They are quick and active in flight, and capable of running and springing rapidly. They may be distinguished from moths by their habit of generally running a few steps after alighting, whereas a moth usually stops where it alights. In taking wing, also, they almost always start off by springing into the air. They are all readily attracted to light.

Characters. H e a d hairy, often warty; *compound eyes* always present, usually wide apart; *ocelli* present or absent, often hidden by hairs; *antennae* many-segmented, elongate, filiform, often ciliate, never pectinate; scape and pedicel stouter than the other segments, the scape sometimes greatly enlarged or elongated. Peculiar eversible *scent-glands* sometimes present on the head (Hydroptilidae, some Sericostomatidae). *Mouth-parts* reduced, so that the insect can take no solid food. *Labrum* usually short and broad (greatly elongated in males of *Stenopsychodes* and *Plectrotarsus*), sometimes with *pilifers* well developed or even in the form of long, projecting processes. *Mandibles* absent or vestigial, never functional. *Maxillae* with well developed palpi, usually five-segmented, but sometimes reduced in the male; distal segment sometimes elongate, flexible or multi-annulate; galea absent or small, lacinia absent. *Labium* with three-segmented palpi, the distal segment usually spoon-shaped, sometimes elongate, flexible or multi-articulate; ligula small or absent. *Hypopharynx* present, usually well-developed.

T h o r a x with short *prothorax* having weakly formed *patagia*. *Mesothorax* larger than *metathorax*, its notum hairier; scuta of both segments divided mid-dorsally, scutella small; *tegulae* present, small. *Legs* formed for running; coxae large, elongated, the middle ones with a posterior meron partially divided off; femora long, strongly built; tibiae long and slender, usually provided with one or two pairs of movable spurs, placed either close to apex (apical spurs) or nearer middle (middle spurs); tarsi five-segmented, ending in a pair of claws. A small *spiracle* lies between propleuron and mesepisternum.

W i n g s heavily clothed with hair, more seldom with scales of a primitive type as well. In flight, fore and hind wings are linked

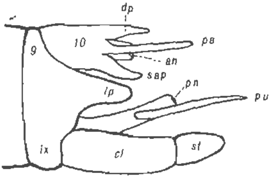


FIG. Y2. Diagrammatic representation of the male terminal appendages in a Caddis-fly, lateral view; *an*, anus; *cl*, clasper; *dp*, dorsal process; *lp*, lateral process; *pa*, preanal appendages; *pn*, penis; *pu*, penuncus; *sap*, subanal plate; *st*, style; *9*, *10*, abdominal tergites; *ix*, ninth sternite. [*R. J. T. del.*

either by a *jugal lobe* at base of forewing (fig. Y1, A, *jl*), or by a row of minute hooks on costa of hindwing. *Venation* (fig. Y1) on the

same general plan as that of the Mecoptera, but with fewer crossveins; *Rs* and *M* with four branches each in the forewing (except in reduced types); in hindwing, *M* has only three branches; Cu_1 always forked in both wings; forewing with the anal veins looped up together to form a double Y-vein. A well defined *wing-spot* (fig. Y1, A, *sp*) present in the angle of the fork formed by R_4 and R_5, except in the Hydroptilidae.

A b d o m e n more or less fusiform, composed of ten segments, of which the first seven have the tergites and sternites well separated by wide pleural membranes, each segment carrying a pair of spiracles; pleura of seg. 5 sometimes specialized, forming a deep pocket on each side, or produced into a slender process. Segment 8 normal in male, but in the female forming an elongate, conical tube without membranous pleura, the sternite often specialized and sometimes carrying a *subgenital plate*. In the male, segment 9 is a highly specialized ring, segment 10 is greatly reduced. The tenth tergite may be produced into a small plate or hood, called the *dorsal process* (fig. Y2, *dp*), homologous with the uncus of Lepidoptera, and generally also carries a pair of *preanal appendages* (*pa*) homologous with the surgonopods of other Orders or socii of Lepidoptera. A *subanal plate* (*sap*) is sometimes developed, homologous with the gnathos of Lepidoptera. The lateral portions of the ninth tergite may also be produced to form

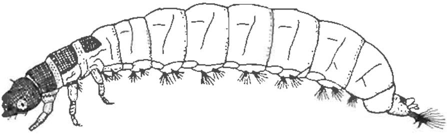
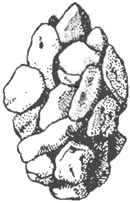
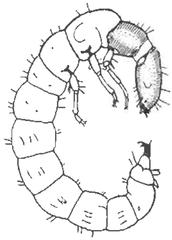
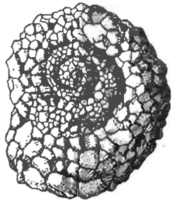


FIG. Y3. Larva of *Hydropsyche colonica* McL., New Zealand. Fam. Hydropsychidae. Length 16 mm. [*R. J. T. del.*





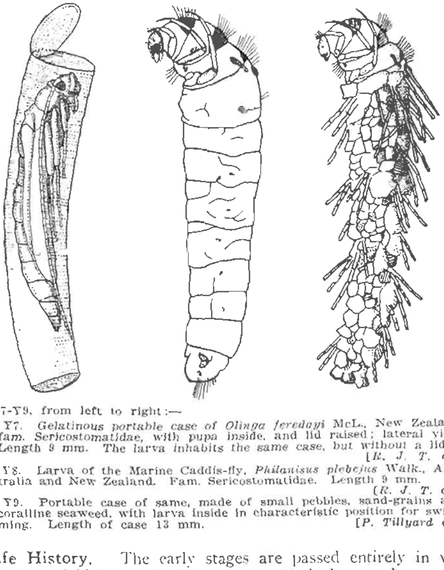


Figs. Y4-Y6, from left to right:—
FIG. Y4. Fixed house of larva of *Hydropsyche colonica* McL., made of pebbles, for pupation. Length 15 mm. [*P. Tillyard del.*
FIG. Y5. *Larva of Helicopsyche albescens* Till., New Zealand. Fam. Sericostomatidae. Length (uncoiled) 10 mm. [*R. J. T. del.*
FIG. Y6. Portable case of same of helicoid form, made of minute pebbles and sand-grains. Greatest diameter 3.7 mm. [*P. Tillyard del.*

lateral processes (*lp*) similar to those found in Micropterygoidea. The ninth sternum carries a pair of prominent gonocoxites called the *claspers* (*cl*) homologous with those of Lepidoptera and Diptera; in

the older families these are two-segmented, the distal portion being the *style* (*st*). The *aedeagus* is usually well developed and consists of the *penis* (*pn*), with or without a penisfilum or titillators, and a pair of *penunci* (*pu*).

Fig. Y1, A shows the venation of an archaic caddis-fly. In systematic work, besides the veins themselves, the presence or absence of the three closed cells *rc*, *mc* and *tc* is of importance. Owing to the method of forking of *Rs*, *M* and Cu_1, five *apical forks* (Af_1 to Af_5) are formed, of which the second (Af_2) always contains the wing-spot (*sp*); the presence or absence of certain of these is of importance. Owing to absence of M_4, Af_4 is never present in hindwing. The structure of the maxillary palpi, the presence or absence of ocelli, and the number of spurs on the tibiae are also important systematic characters. The last is usually given as a *short formula*; e.g. "spurs 2-2-4" means one pair of spurs on fore and middle tibiae, two pairs on hind.



Figs. Y7-Y9, from left to right:—

Fig. Y7. Gelatinous portable case of Olinga feredayi McL., New Zealand, *fam. Sericostomatidae, with pupa inside, and lid raised; lateral view. Length 9 mm. The larva inhabits the same case, but without a lid.* [*R. J. T. del.*

Fig. Y8. Larva of the Marine Caddis-fly, *Philanisus plebejus* Walk., Australia and New Zealand. Fam. Sericostomatidae. Length 9 mm. [*R. J. T. del.*

Fig. Y9. Portable case of same, made of small pebbles, sand-grains and coralline seaweed, with larva inside in characteristic position for swimming. Length of case 13 mm. [*P. Tillyard del.*

Life History. The early stages are passed entirely in water. The *eggs* are laid in a gelatinous mass, attached to rocks, roots of aquatic plants, etc., in water. The *larvae* (figs. Y3, Y5, Y8) are caraboid or eruciform, but without any abdominal prolegs, except only the anal pair, which are usually strongly hooked; first abdominal segment often with a mid-dorsal and two lateral processes, which, in conjunction

with the hooked anal prolegs, assist the larva in holding its case in position; gill-tufts are frequently developed on various parts of the body. The larvae construct either portable cases, fixed abodes, or flimsy galleries; the portable cases (figs. Y6, Y7, Y9) are usually made either of twigs, pieces of leaves, sand, small pebbles, etc., sewn together with silk, or of a gelatinous secretion from the larva itself. The fixed abodes (fig. Y4) are usually attached to rocks and are made of small pebbles cemented together to make a house; other species form conical nets of silk and débris to catch the food brought down by the stream. Long, flimsy galleries may be formed in mud, or on the surface of rocks, logs, etc., either of pure silk, or with algae or dirt woven into them for protection.

The *pupa* (figs. Y7, Y10) is a *pupa libera,* often enclosed in a gelatinous *cocoon* within the larval case. It is capable of freeing itself

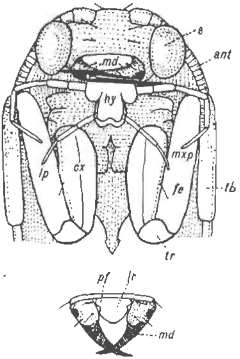


FIG. Y10. Ventral view of head and prothorax of pupa of *Hydrobiosis umbripennis* McL., New Zealand, fam. Rhyacophilidae, to show the horizontally placed, crossed mandibles (*md*) used for cutting open the gelatinous cocoon. Below, mandibles of mature pupa in position for cutting, exposing labrum (*lr*) with small pilifers (*pf*); *ant*, antenna; *cx*, the divided fore coxa; *e*, eye; *fe*, fore femur; *hy*, trilobed hypopharynx covering labium; *lp*, labial palp; *lr*, labrum; *md*, mandible; *mxp*, maxillary palp; *pf*, pilifer; *tb*, fore tibia; *tr*, fore trochanter. (x 16) [*R. J. T. del.*

from the cocoon by means of a pair of powerful mandibles (fig. Y10, *md*) before disclosing the imago at the surface of the water.

Distribution. Ten families are represented in Australia, but six only of these have so far been recorded for N.Z. A number of genera are common to the two countries. Nearly sixty species are known from Australia, less than fifty from N.Z. But the Order forms a more noticeable feature of the fauna of N.Z. than of Australia, the species occurring in much greater abundance, as is only to be expected from the much greater number of permanent rivers. The N.Z. species are also, on the average, of larger size, though of duller colouration, than the Australian.

Fossil History. The earliest known fossil Caddis-flies are those found in the European Lias, placed in the extinct family Necrotauliidae, very closely allied to the existing Rhyacophilidae. Numerous Tertiary Caddis-flies are known, the Order being particularly well represented in Baltic Amber (Oligocene). No fossil Trichoptera have yet been recorded from Australia, but the Upper Permian Paramecoptera (p.

472) were undoubtedly ancestral to the common stem of the Trichoptera and Lepidoptera, which must have existed in the Trias.

Economics. The Order is entirely beneficial, the larvae not only forming a most important article of diet for fresh-water fishes, but also helping effectively to control the growth of water-weeds. Trout eat the larvae ravenously, swallowing their cases whole and digesting their contents at leisure; they also eat the adults, but more sparingly. Birds, lizards, frogs and dragonflies also devour caddis-flies.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES*

Order TRICHOPTERA 58 (47)

Suborder	Superfamilies and families
Suborder AEQUIPALPIA 41 (32)	I. RHYACOPHILOIDEA 36 (28) 1. Rhyacophilidae 1 (12) 2. Philopotamidae 2 (0) 3. Polycentropodidae 7 (2) 4. *Hydropsychidae* 11 (5) 5. Psychomyiidae 1 (0) 6. Calamoceratidae 5 (2) [Odontoceridae] 7. Leptoceridae 9 (7) [Molannidae] II. HYDROPTILOIDEA 5 (4) 8. *Hydroptilidae* 5 (4)
Suborder INAEQUIPALPIA 17 (15)	III. PHRYGANEOIDEA 2 (0) [Phryganeidae] 9. Limnephilidae 2 (0) IV. SERICOSTOMATOIDEA 15 (15) 10. Sericostomatidae 15 (15)

The Order is divided into two Suborders, as follows:—

Maxillary palpi five-segmented and of similar form in both sexes. Suborder AEQUIPALPIA

Maxillary palpi five-segmented in the female only, those of the male reduced to four, three or two segments Suborder INAEQUIPALPIA

Suborder AEQUIPALPIA

This Suborder contains ten families, one of which is very different from all the rest, so that two distinct superfamilies can be recognized, as follows:—

Minute insects with very narrow wings and greatly reduced venation; hindwings with the *fringe-hairs as long as the breadth of the wing, or* longer; forewing with the distal end carrying thickened, upright hairs. II. HYDROPTILOIDEA

Insects of larger size, not as above, and having the fringe-hairs of the hindwing always much shorter than the breadth of the wing I. RHYACOPHILOIDEA

Superfamily I. RHYACOPHILOIDEA

Of the nine families included in this group, two, the Odontoceridae and Molannidae, have not yet been recorded from Australia or New Zealand. They are, however, included in the *following Key, as our present knowledge of the Aus*tralian fauna is very fragmentary:—

*The Australian totals include a number of undescribed species present in the author's collection.

1. Last seg. of maxillary palp only slightly or scarcely longer than the others, not secondarily annulated, and usually not flexible. 2
Last seg. of maxillary palp usually much longer than the others, always flexible, and secondarily annulated (fig. Y1, D). 6
2. Ocelli present. Fam. 1. RHYACOPHILIDAE
Ocelli absent. 3
3. Median cell (*mc*) of forewing present, closed. Fam. 6. CALAMOCERATIDAE
Median cell of forewing absent. 4
4. Radial cell (*rc*) of forewing present, closed. 5
Radial cell of both wings absent. Fam. MOLANNIDAE
5. Forewing with both branches of *Rs* forked, i.e., both Af_1 and Af_2 present (usually also the other apical forks present). Fam. ODONTOCERIDAE
Forewing with only the upper branch of *Rs* forked, i.e., Af_2 absent; palpi shaggily hairy. Fam. 7. LEPTOCERIDAE
6. Ocelli present. Fam. 2. PHILOPOTAMIDAE
Ocelli absent. 7
7. Fore tibiae with three spurs, two apical and one middle. Fam. 3. POLYCENTROPODIDAE
Fore tibiae with less than three spurs. 8
8. Forewing with first apical fork (Af_1) present. Fam. 4. HYDROPSYCHIDAE
First apical fork (Af_1) absent in both fore and hind wings. Fam. 5. PSYCHOMYIIDAE

Family 1. **Rhyacophilidae** [Aus. 1, N.Z. 12]. This family contains the most primitive of living Trichoptera, the palpi being of the most generalized form, the fore and hind wings of the most nearly similar shape and venation, and the larvae carnivorous, either roaming freely or living in silken galleries on rocks in swift-running rivers. Only a single species, *Hydrobiosis stigma* Ulm., is so far recorded from Australia, but the family is well represented in New Zealand. *Hydrobiosis umbripennis* McL. (pl. 26, fig. 4) is a fairly common, dark brown species, exceedingly agile. The allied genera *Hydrobiosella, Hydrochorema, Synchorema* and *Neurochorema* contains mostly smaller species, the last-named being remarkable for the difference in venation in the two sexes. *Psilochorema*, with two common species, *Ps. mimicum* McL., and *Ps. confusum* McL., is an extraordinary genus with all the veins arranged closely parallel in the distal part of the wing. *Tiphobiosis* contains small species with the apex of the forewing pointed (as in the Lepidopterous family Micropterygidae) and the radial cell absent; these insects stand near the starting-point of the line of evolution of the Hydroptiloidea.

Family 2. **Philopotamidae** [Aus. 2, N.Z. 0]. An offshoot of the previous family, specialized by the extraordinary development of the last segment of the maxillary palpi. *Chimarrha australica* Ulm. is a black species from N. Queensland. *Dolophilus michaelseni* Ulm. a rare form from Western Australia.

Family 3. **Polycentropodidae*** [Aus. 7, N.Z. 2]. Allied to the previous family, but with ocelli absent and spurs always 3-4-4; jugal lobe well developed; venation of forewing much on same plan as that of Rhyacophilidae, but hindwing broader, with well-developed anal region. Larvae mostly carnivorous, living in silken galleries either in running or stagnant waters, and having the abdomen often of a semi-transparent, pinkish colour. *Polyplectropus puerilis* McL. (pl. 26, fig. 5) is a handsome blackish species found in both countries, the larvae living in still water. Some of the most beautiful caddis-flies in Australia belong to the fine genus *Stenopsychodes*, whose larvae live in fast mountain streams; *S. montana* Till. (pl. 26, fig. 6), with speckled orange and black forewings, occurs in the Blue Mountains and Mount Kosciusko; the lovely *S. melanochrysa* Till. (pl. 11, fig. 22) is found on the Dorrigo Plateau, N.S.W.; and the handsome fawn-coloured *S. hiemalis* Till. (pl. 26, fig. 7) occurs round Sydney in mid-winter. The males of this genus have the labrum elongated to form a slender rostrum.

Family 4. **Hydropsychidae** [Aus. 11, N.Z. 5]. Allied to the previous family, but the fore tibiae never have three spurs; the forewing is either subtriangular or elongate in shape, and the hind has a well-developed anal area.

*Genus *Polycentropus* from Greek *polus* many, *kentron* spur, and *pous*, gen. *podos* foot, stem *polycentropod-*, hence family Polycentropodidae.

Larvae (fig. Y3) carnivorous, living either in fixed houses (fig. Y4) formed of small pebbles cemented together with silk and attached to rocks and logs in running water, or, more rarely, constructing a series of conical nets across the the surface of a shallow mountain stream, one larva living in the apex of each net, and feeding on the small animals caught in it. The larvae possesses numerous gill-tufts, and die very quickly if removed from the water. The genus *Hydropsyche* is represented by five species in New Zealand, active, brown or blackish caddis-flies usually abundant near fast rivers. *H. colonica* McL. (pl. 26, fig. 8) is easily the commonest caddis-fly in New Zealand, and sometimes becomes a perfect nuisance in hydro-electric works, being attracted to the light in countless thousands at night, and getting into the clothes, eyes and hair of the workmen. The chief genus in Australia and Tasmania is *Smicridea*, which contains the lovely Snow-flake Caddis-flies. The males have pure white wings, sometimes with dark markings, and fly in clouds on the mountain streams in the late afternoon, rising and falling rhythmically and giving the appearance of a miniature snowstorm. The females are dull brownish insects which seldom escape from the water; for, as soon as one emerges from the pupal shell, the whole swarm of males descend upon her, and she is often drowned in the act of releasing her eggs. The specialized subfamily Macronematinae, containing rather large species with very long antennae and long, slender forewings, is represented in Australia by several species of *Macronema*, of which the lovely orange and black *M. pulchripenne* Till. is the most beautiful.

Family 5. **Psychomyiidae** [Aus. 1, N.Z. 0]. An offshoot from the previous family, represented in Queensland by the single species *Ecnomus continentalis* Ulm., belonging to a well-known Oriental genus.

Family 6. **Calamoceratidae** [Aus. 5, N.Z. 2]. A well-defined family with more or less broadly subtriangular forewings, having all five apical forks present, and *mc* closed, hindwings shorter than forewings, and having either *Sc* ending on R_1, or R_1 ending on R_2; maxillary palpi normal, strongly formed and very hairy. Larvae vegetarian, living in a cylindrical or subcylindrical case, formed of grit, sand, etc., both in rapid and still water. The graceful species of the genus *Anisocentropus*, mostly rich brown and fulvous in colour, occur from N. Queensland to Tasmania in the neighbourhood of still or slowly moving water; *A. latifascia* Walk. (pl. 26, fig. 9) is the commonest species. The remarkable genus *Philorheithrus* occurs both in Tasmania and New Zealand, with one rare species also in Eastern Australia; the males have the piliters developed into elongated hairy processes. These insects rest head downwards with their wings folded in such a way that they resemble short, broken twigs. *Ph. agilis* Huds. (pl. 26, fig. 10) is fairly common in New Zealand on rapid streams; its larva forms an almost cylindrical case of tiny pebbles; the imago has a dashing, bewildering flight.

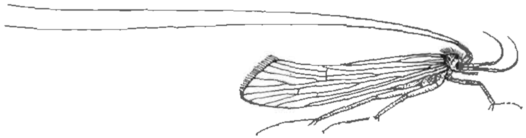


FIG. Y11. *Notanatolica magna* Walk., male, Australia, lateral view, with hairs of wings removed to show venation. Fam. Leptoceridae. Length of forewing 20 mm. [*R. J. T. del.*

Family 7. **Leptoceridae** (Long-horned Caddises) [Aus. 9, N.Z. 7]. A very distinct family, in which the antennae are excessively long, especially in the males; the last segment of the maxillary palpi is flexible and very hairy, but not unduly elongated or secondarily annulated; the forewings are long and narrow, with Af_2 always absent, and *mc* is absent in both wings. Larvae vegetarian, living in portable cases, cylindrical or conical, formed of vegetable débris, such as pieces of twigs, grass or leaves, mostly in still or sluggish water; a few species have larvae which tunnel in submerged logs. The genera *Notanatolica*, *Triplectides*, *Oecetis*, and *Setodes* occur in both countries. In New Zealand the large *T. obsoleta* McL., expanding up to 40 mm., and the smaller, slenderer and more prettily marked *T. amabilis* McL. (pl. 26, fig. 11) are both common, as is also the very slender *O. unicolor* McL.; its larva lives in lakes, forming its case of the water-weed

Nitella, and is an important article of diet for the introduced trout. The Australian *N. magna* Walk. (fig. Y11) and the closely allied *N. cognata* McL. in New Zealand are both very common species of fairly large size. At Broken Hill, in the far west of N.S.W., an undescribed species with cream-coloured wings covered with scales comes freely to light; but what its life history may be, in so arid a region, is quite unknown.

Superfamily II. HYDROPTILOIDEA

Family 8. **Hydroptilidae** [Aus. 5, N.Z. 4]. These tiny insects, sometimes called Micro-trichoptera, cannot be confused with any other Caddis-flies, but are frequently mistaken for Tineoid moths, which they closely resemble superficially. The absence of scales and haustellum, and the drooping labial palpi, will suffice to distinguish them from moths. Most of them fold their wings flatly down upon the abdomen. Their larvae feed on slime algae, constructing tiny cases formed of a gelatinous secretion, often of a peculiar shape. The adults congregate on trees and bushes overhanging water where slime algae occur, and may be taken in large numbers by sweeping. At least five well-marked species occur in Australia, but have not yet been described. *Zelandoptila* is a rare, archaic genus found in New Zealand, which has all apical forks present except Af_1 and shows evident relationship with the reduced Rhyacophilid genus *Tiphobiosis; Z. moselyi* Till. expands 10 mm. The other New Zealand species belong to *Oxyethira* and *Paroxyethira* and are tiny insects with very reduced venation and an expanse of 5-7 mm. *O. albiceps* Eat. is a common, whiteheaded species whose larva forms a tiny, flask-shaped case.

Suborder INAEQUIPALPIA

The three families included in this Suborder are all specialized by reduction of the number of segments in the maxillary palpi of the males, and in many respects are the most highly organized and dominant groups of Caddis-flies existing. They fall naturally into two distinct superfamilies, as follows.—

Segments of maxillary palpi of male not differing in form from those of female. III. PHRYGANEOIDEA

Segments of maxillary palpi of male highly modified, differing greatly from those of female IV. SERICOSTOMATOIDEA

Superfamily III. PHRYGANEOIDEA

This group, dominant in the Northern Hemisphere, is entirely absent from New Zealand and barely represented in Australia. The two families may be distinguished as follows (the Phryganeidae being absent from both countries):—

Maxillary palpi of male with four segments. (Fam. PHRYGANEIDAE)

Maxillary palpi of male with three segments. Fam. 9. LIMNEPHILIDAE

Family 9. **Limnephilidae** [Aus. 2, N.Z. 0]. A highly specialized family, in which the wings are less densely clothed with hair than usual, and a more or less complete *transverse cord* (*cf* Nemouridae, p. 119) is formed by alignment of the cross-veins in forewings at about one-third from apex. Larva vegetarian, living in a tubular case of very varying form and structure, in either still or running water. Two undescribed species, apparently with affinity to South American forms, are known to occur, one in Tasmania and Victoria, the other on the Blue Mountains; both are rare.

Superfamily IV. SERICOSTOMATOIDEA

This group contains a single highly specialized family, and includes a large number of very diverse forms all united by the high specialization of the maxillary palpi of the male (fig. Y1, C), which are reduced to 2-3 segments and are of quite different form from those of the female. A detailed study of the group would probably result in its separation into several distinct families.

Family 10. **Sericostomatidae** [Aus. 15, N.Z. 15]. Antennae usually thickened, with large scape, often longer than the head, very hairy; ocelli absent, except in *Plectrotarsus;* wings nearly always very hairy, so that the venation is difficult to make out; venation very variable, often highly specialized, the forewings of the male frequently with longitudinal folds or pockets. Larvae vegetarian, living in portable cases, sometimes formed of a gelatinous secretion (fig. Y7), but usually of sand, minute pebbles, or vegetable material; shape cylindrical, conical, curved or coiled; mostly in running water.

This family is well represented in both countries by a number of peculiar and isolated genera, most of which will not fit into any of the recognized subfamilies. Most of the genera have the maxillary palpi in the males held

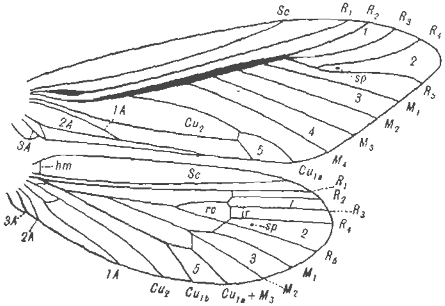


FIG. Y12. *Pycnocentria evecta* McL., male, New Zealand. Fam. Sericostomatidae. Wing-venation, to show the longitudinal fold in the forewing, from which all the branches of *Rs* and *M* arise. Lettering as in fig. A8, p. 22; except *ir*, inter-radial cross-vein closing *rc*, radial cell; *sp*, wing-spot; *1, 2, 3, 4, 5*, the five apical forks. [R. J. T. del.

vertically upwards in front of the face (fig. Y1, C). The finest species belong to the New Zealand *Oeconesus* group, containing the three genera, *Oeconesus*, *Pseudoeconesus* and *Zelandopsyche*. *Oe. maori* McL. (pl. 26, fig. 12) is the best known species, of a brownish colour with strongly irrogated forewings. *Z. ingens* Till. (pl. 26, fig. 13), a rare, alpine species, is the largest known Caddis-fly in New Zealand; its larva constructs a huge, cylindrical case made of small pieces of twigs of *Nothofagus* placed transversely and very neatly sewn together. This group superficially resembles the Limnephilidae. *Plectrotarsus gravenhorsti* Kol. (pl. 26, fig. 14) is an extraordinary insect found in Tasmania and Victoria, sometimes with orange and black forewings, sometimes quite black; it has the labrum prolonged into a slender rostrum in the male, and ocelli are present. The Marine Caddis-fly, *Philanisus plebejus* Walk. (fig. Y13) is another aberrant type; its larva (fig. Y8) feeds on Coralline Seaweed in rock-pools between tide-marks, and appears to be generally distributed round the coasts of both countries. The subcylindrical case (fig. Y9) is cunningly contrived from small pieces of the food-plant and other objects, so that the larva is most difficult to detect. The imago frequents rocky coasts and is very active. The *Pycnocentria*-group is well represented in both countries, but only the New Zealand species have been fully dealt with; the venation is more or less reduced, and the males of some of the genera have a long groove or pocket on the forewing. *P. evecta* McL. (pl. 26, fig. 15) and the much smaller black *P. funerea* McL. (pl. 26, fig. 16) are both common in New Zealand. *Olinga feredayi* McL. (pl. 2, fig. 22) is a very handsome allied species, common in New Zealand, in which the wings are covered with scales of a primitive form, giving them a glistening appearance; the male is brownish, with a subdorsal fold on the

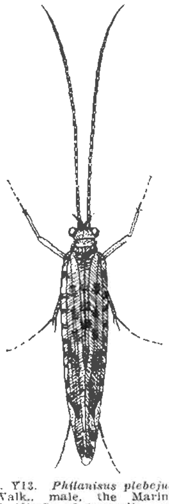


FIG. Y13. *Philanisus plebejus* Walk., male, the Marine Caddis-fly of Australia, and New Zealand. Fam. Sericostomatidae. Length, exclusive of antennae, 8 mm. [R. J. T. del.

forewing curving upwards near termen and marked by a band of orange scales; the female has rich golden yellow forewings. The larva makes a curved, subcylindrical case formed entirely of a transparent, brownish, gelatinous secretion (fig. Y7). Several small, prettily marked species (pl. 26, fig. 17) are found resting in boggy places at high altitudes in Tasmania, but have not yet been described. The *Helicopsyche*-group includes the small species of the world-wide genus *Helicopsyche* and the Australian *Saetotricha*, remarkable in having M_2 of hindwing switched over on to M_3, so that M_4 (never present in hindwing of Trichoptera, owing to absence of M_2) appears to be present. The larvae of *Helicopsyche* (fig. Y5) construct small helicoid cases (fig. Y6) of sand or other mineral grains, and is greatly elongated in order to accommodate itself to its queer abode. Three species occur in New Zealand, *H. zelandica* Huds. and *H. albescens* Till. both being common. The genus is also not uncommon in Australia.

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CHAPTER XXVIII

Order LEPIDOPTERA

(Moths and Butterflies)

This immense Order, represented by nearly 8,000 species in Australia and 1,200 in New Zealand, is very closely related to the preceding one, with which it has many characters in common. All Lepidoptera, however, have *scales* on the wings, and, even in the most primitive types, these scales are of a more specialized form than those found in the few Trichoptera which possess them. Most Lepidoptera also

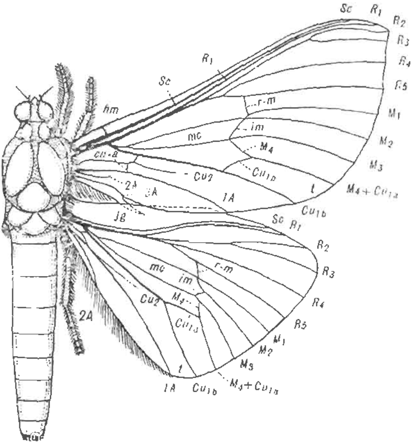


FIG. Z1. *Charagia virescens* Dbd., the New Zealand Giant Swift Moth, male. Fam. Hepialidae. Lettering as in fig. A8, p. 22; except *cu-a*, cubita-anal cross-vein; *im*, inter-median cross-vein; *jg*, jugum; *mc*, median cell; *r-m*, radio-median cross-vein. [*R. J. T. del.*

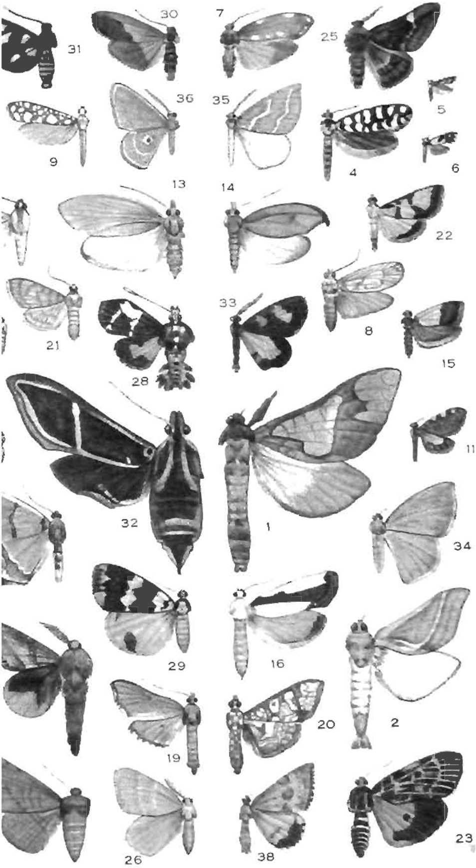
possess a coiled tongue, or *haustellum*, never present in Trichoptera, while only very few (Micropterygoidea and some Tineoidea) have the well-developed, five-segmented maxillary palpi found in Caddis-flies.

PLATE 27

AUSTRALIAN LEPIDOPTERA (MOTHS)

All figures natural size

1. *Charagia splendens* Sc. (Fam. HEPIALIDAE), female.
2. *Charagia astathes* Turn., pink var. (Fam. HEPIALIDAE), male
3. *Nemotois sparsella* Walk. (Fam. TINEIDAE).
4. *Mocrarchis australasiella* Don. (Fam. TINEIDAE).
5. *Comodica tigrina* Turn. (Fam. TINEIDAE).
6. *Opogona comptella* Walk. (Fam. TINEIDAE).
7. *Lactura caminaea* Meyr. (Fam. HYPONOMEUTIDAE).
8. *Lactura erythractis* Meyr. (Fam. HYPONOMEUTIDAE).
9. *Atteva niphocosma* Turn. (Fam. HYPONOMEUTIDAE).
10. *Simaethis basalis* Feld. (Fam. GLYPHIPTERYGIDAE).
11. *Cebysa leucoteles* Walk. (Fam. GLYPHIPTERYGIDAE), male.
12. *Hypertropha tortriciformis* Gn. (Fam. COPROMORPHIDAE).
13. *Wingia lambertella* Wing. (Fam. OECOPHORIDAE).
14. *Tortricopsis aurata* Walk. (Fam. OECOPHORIDAE).
15. *Coesyra dichroella* Zell. (Fam. OECOPHORIDAE).
16. *Xylorycta porphyrinella* Walk. (Fam. XYLORYCTIDAE)
17. *Striglina pyrrhata* Walk. (Fam THYRIDIDAE).
18. *Agrotera pictalis* Warr. (Fam. PYRAUSTIDAE).
19. *Margaronia suralis* Gn. (Fam. PYRAUSTIDAE).
20. *Margaronia cantholis* Walk. (Fam. PYRAUSTIDAE).
21. *Hyalobathra miniosalis* Gn. (Fam. PYRAUSTIDAE).
22. *Pyrausta achocalis* Walk (Fam. PYRAUSTIDAE).
23. *Cardamyla carinentalis* Walk (Fam. PYRALIDAE).
24. *Pinara obliqua* Walk. (Fam. LASIOCAMPIDAE), male.
25. *Nataxa flavescens* Walk. (Fam. ANTHELIDAE).
26. *Porthesia lutea* Fabr. (Fam. LYMANTRIIDAE).
27. *Earias smaragdina* Butl. (Fam. NOCTUIDAE).
28. *Hecatesia fenestrata* Bd. (Fam. NOCTUIDAE), male.
29. *Castulo shepherdi* Newm. (Fam. ARCTIIDAE).
30. *Scoliacma bicolor* Bd. (Fam. ARCTIIDAE).
31. *Syntomis annulata* Fabr. (Fam. SYNTOMIDAE).
32. *Cizara ardeniae* Lew. (Fam. SPHINGIDAE).
33. *Ctimene synestia* Meyr. (Fam. BOARMIIDAE).
34. *Aplochlora vivilaca* Walk (Fam. BOARMIIDAE).
35. *Euloxia meandraria* Gn. (Fam. GEOMETRIDAE).
36. *Chlorocoma cadmaria* Gn. (Fam. GEOMETRIDAE).
37. *Agathia lactata* Walk. (Fam. GEOMETRIDAE).
38. *Euphyia perornata* Walk. (Fam. LARENTIIDAE).



yard pinx.

AUSTRALIAN LEPIDOPTERA (MOTHS)

There are also some constant differences in the venations of the two Orders, which are mentioned below.

Characters. Head small, hairy or scaly, often greatly so; *compound eyes* always present, separated; *ocelli* either two only, or absent: *antennae* very variable in length and form, composed of numerous segments, originally moniliform and shorter than forewing, but often lengthened, filiform, ciliate, pectinate, thickened, hooked, or clubbed at the tip; frequently those of the male are of a more specialized form than those of the female. *Epicranium, frons* and *clypeus* well developed, but the mouth-area is much reduced. *Mouth-parts* nearly always of a specialized sucking type, (fig. Z2, C) in which the *labrum* is reduced to a short, broad piece, often with prominent side-lobes or *pilifers* (fig. Z3, B, *pf*), the *mandibles* are absent or reduced to non-functional vestiges without articulation, the *labium* reduced to a small basal piece carrying a pair of large, hairy or scaly, three-segmented palpi (sometimes reduced), and the *maxillae* (fig.

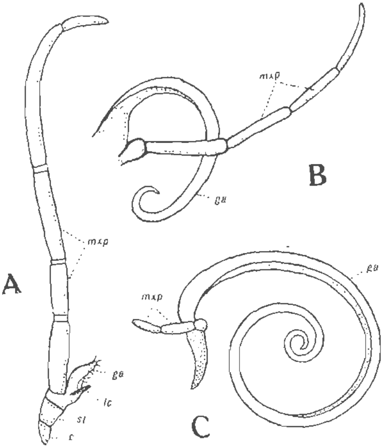


FIG. Z2. Various forms of Lepidopterous maxillae (all much enlarged); A, from *Sabatinca chrysargyra* Meyr. (fam. Micropterygidae); B, from *Monopis ethelella* Newm. (fam. Tineidae, subfam. Tineinae); C, from *Titanomis sisyrota* Meyr. (fam. Tineidae, subfam. Tineinae). Note the lengthening of the galea (*ga*) to form the haustellum. Lettering as in fig. A5, p. 16. [*R. J. T. del.*

Z2) have the palp (*mxp*) generally reduced or absent, the lacinia (*la*) absent, and the galea (*ga*) greatly elongated; the two galeae together form a complete tube or *haustellum*, which is the sucking organ, capable of being coiled up when at rest, or extended straight out when required for sucking the nectar of flowers. Numerous forms occur with all the mouth-parts vestigial except the labial palpi. True

functional mandibles, together with primitive maxillae (fig. Z2, A) having lacinia, galea and palp of normal form, occur in the archaic family Micropterygidae, which also possesses a well-formed but specialized labrum, epipharynx and hypopharynx.

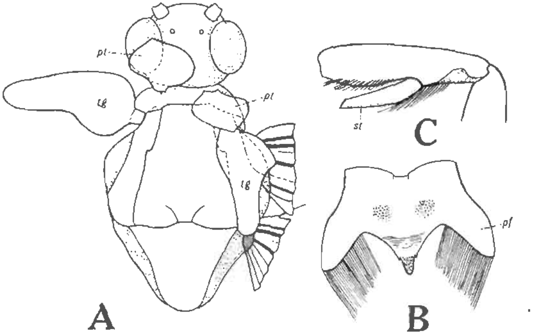


FIG. Z3. A, head and thorax of *Persectania ewingi* Wwd., fam. Noctuidae, to show positions of patagia (*pt*) and tegulae (*tg*); those of the left side are turned backwards and outwards to show basal attachments; B, labrum and pilifers (*pf*) of same, greatly enlarged; C, fore tibia of *Titanomis sisyrota* Meyr., fam. Tineidae, subfam. Tineinae, to show strigil (*st*).
[A and C, *R. J. T. del*; B, *A. Philpott del.*

Thorax:—*Prothorax* small and collar-like; in all but the oldest forms it carries a pair of dorso-lateral processes directed backwards, termed *patagia** (fig. Z3, A, *pt*). *Mesothorax* usually very large, with strongly built notum having a very large, convex scutum and a smaller scutellum; in some of the higher forms this scutellum projects backwards as a lobe above the base of the abdomen; from the sides of the mesonotum, anteriorly, there project a pair of backwardly directed processes called the *tegulae*,* (also called shoulder-tufts, paraptera or scapulae (fig. Z3, A, *tg*) usually heavily covered with scales; mesopleura with distinct episternum and epimeron; mesosternum small. *Metathorax* not much smaller than mesothorax in some of the most archaic forms (Homoneura), but reduced in all the rest, with the metanotum much smaller than mesonotum and having the metascutum placed at a lower level than, and partially beneath the mesoscutellum, and also partially divided from behind by the small metascutellum; metapleura well developed; metasternum small. A pair of *spiracles* present in the membrane between pro- and mesothorax. *Legs* generally slender, of variable length, always more or less covered with scales or tufts of hairs; coxae large, more or less elongated, those of middle legs with a definite meron; trochanters very small; femora usually not very stout, shorter than tibiae; tibiae slender, medium or long; tibial spurs normally 0-2-4, more rarely 0-2-2, in some families absent; fore

*Unfortunately many Lepidopterists continue to invert the usage of these two terms, though Sharp (Camb. Nat. Hist., vol. II, pp.311-2) correctly defined their meanings in 1909.

tibiae nearly always with a peculiar projecting process, or *strigil*, (fig. Z3, B, *st*) on its inner side, possibly a comb or cleaning organ for the antennae; tarsi usually slender, fairly long, almost always 5-segmented and ending in a pair of claws, beneath which is a small process or empodium.

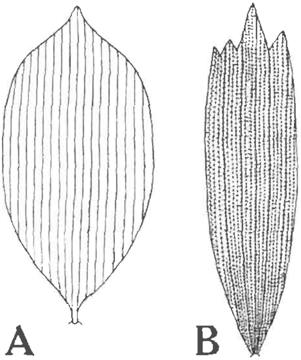


FIG. Z4. Scales from Lepidopterous wings. A, broad scale from *Sabatinca incongruella* Walk., fam. Micropterygidae; B, medium scale from *Mnesarchaea hamadelpha* Meyr., fam. Mnesarchaeidae. (x 600).
[*R. J. T. del.*

W i n g s in all the more archaic forms held roof-wise over the back, so that the posterior margins, or *dorsa*, meet or fold dorsally over the abdomen; in higher groups the wings may be held horizontally, either completely spread out, or with the forewings forming a triangle and covering the hind; or they may be held vertically upwards with their upper surfaces pressed close together and their under surfaces exposed (as in most Butterflies when at rest). In most forms, a definite tornus (fig. Z1, *t*, also p. 25 and fig. A8, *tn*) is developed on both wings; that portion between apex and tornus is called the *termen*, that between tornus and base the *dorsum* (posterior margin). *Wing-membrane* always carrying *scales* (fig. Z4), and almost always completely covered with them. These scales are really minute, specialized hairs (macrotrichia); they occur on both surfaces of the wing, and each scale is inserted in a very minute socket. Many forms have all shapes of scales on the wing, ranging from slightly flattened hairs to broadly oval scales. Scales with a serrated distal margin are very common also. The peculiar scales termed *androconia* are found in connection with special glands on the wings of the males of Butterflies and a few Moths. The most primitive type of scale (fig. Z4, A) is oval, with numerous longitudinal striae but no pigment (Micropterygidae); a higher and much more frequent type of scale has tiny transverse strioles or connecting bars between the striae and also carries pigment (fig. Z4, B). The minute hairs called *aculeae* (microtrichia) are obsolete except in Micropterygoidea and a few Tineoidea. A comb of stiff, straight

hairs, directed upwards and slightly backwards, is present on vein Cu_1 on the upper side of the hindwing in some Tineoidea and Pyraloidea; it is called the *cubital pecten*.

The *Wing-venation* (fig. Z5, B) of a typical Lepidopteron is at first sight of a very peculiar type, consisting of a large, closed *basal cell* with a number of veins radiating out from it. In a typical forewing, such as that of a Butterfly, twelve such veins were recognized; of these the first and last sprang from the base of the wing, while all the rest arose from the basal cell. These veins were numbered from before backwards *12, 11, 10, ... 2, 1*. In a typical hindwing, only eight such veins were to be seen, and were numbered *8, 7, ... 2, 1*. If additional posterior veins occurred, the numbers *1a, 1b, 1c*, were used (see Table, p. 401). This method was convenient for descriptive work, but took no account of the homologies of the veins, nor of the evolution of the peculiar type of venation. By a study of the pupal wing-tracheation, the true nature of the basal cell and the true homologies of the veins can be easily determined, as can be seen from fig. Z5, A and B. Taking the forewing first, *Sc* is nearly always simple (forked distally or with a humeral veinlet, *hm*, only in a few very archaic types); *R* is a strong vein with a four-branched *Rs*, sometimes with a closed radial cell (*rc*), called the *areole* (fig. Z22); *M* has three free branches, and a fourth, M_4, fused with Cu_{1a} and generally appearing only as a short, connecting cross-vein; in a few archaic types only, a fifth branch, M_5, connects with Cu_1 basally, forming a cubito-median Y-vein; a closed median cell (*mc*) is present only in some archaic types; Cu_1 is a strong, convex vein, forming the posterior border of the basal cell, and dividing distally into Cu_{1a} and Cu_{1b}; Cu_2 is a weak, concave vein, often incomplete basally, frequently entirely obsolete; anal veins variable, *1A* usually complete, *2A* usually forming a short basal loop below it, *3A* seldom present.

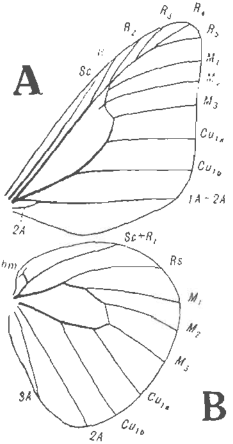


FIG. Z5. A, Tracheation of pupal wing of the Butterfly *Euploea corinna* W.S.M., fam. Nymphalidae; B, Wing-venation of imago of same. Lettering as in fig. A8, p. 22. (*R. J. T. del.*)

In the oldest existing types (Suborder Homoneura, figs. Z1, Z18, Z21) the venation of the hindwing is closely similar to that of the fore, but its anal veins are not looped. In all the rest (Suborder Heteroneura), the hindwing has *Sc* and R_1 fused together for their distal half or more, the free basal portion of R_1 sometimes appearing simply as an oblique or transverse veinlet below *Sc*, often obsolete or obliterated through more complete fusion of the two veins; further, *Rs* is reduced to a simple vein without any branches. Cu_2 is present as a complete vein only in the more primitive groups; *1A* and *2A* fuse together near

base to form a Y-vein, which becomes a simple vein by loss of *1A* in the higher groups; *3A* is often present.

We can now understand the formation of the *basal cell*. Originally it was bounded by *R* and portion of *Rs* above, by Cu_1 below, and by *r-m*, *im*, M_4 and the basal piece of Cu_{1a} distally, (these short pieces being called *discocellulars*), and was crossed longitudinally by *M*, dividing distally into two main branches. The basal cell became a complete cell, devoid of veins, by the elimination of *M* and its branches within the cell, though in all cases the corresponding parts of trachea *M* are to be seen in the pupal wing. Further, in some of the higher groups the stem of R_{4+5} (called the *chorda*) above the basal cell is also eliminated, thus incorporating the areole within the cell, forming a single whole or *areocel*, (figs. Z59, Z64, Z70).

The above facts are set forth clearly in the following Table:—

TABLE SHOWING THE COMSTOCK-NEEDHAM AND NUMERICAL NOTATIONS FOR THE VENATION OF LEPIDOPTERA.

Veins.	Forewings of whole Order and Hindwings of Homoneura.		Hindwings of Heteroneura only.	
	C-N Notation.	Numerical Notation.	C-N Notation.	Numerical Notation.
Subcosta	*Sc*	*12*	$Sc+R_1$	*8*
Radius	R_1	*11*		
Radial Sector	*Rs*	—	*Rs*	*7*
First Branch	R_2	*10*	—	—
Second Branch	R_3	*9*	—	—
Third Branch	R_4	*8*	—	—
Fourth Branch	R_5	*7*	—	—
Media:—	*M*	—	—	—
First Branch	M_1	*6*	M_1	*6*
Second Branch	M_2	*5*	M_2	*5*
Third Branch	M_3	*4*	M_3	*4*
First Cubitus:—	*Cu*	—	Cu_1	—
Upper Branch	Cu_{1a}	*3*	Cu_{1a}	*3*
Lower Branch	Cu_{1b}	*2*	Cu_{1b}	*2*
Second Cubitus	Cu_2	*1c*	Cu_2	*1c*
First Anal	*1A*	*1b*	*1A*	*1b*
Second Anal	*2A*		*2A*	
Third Anal	*3A*	*1a*	*3A*	*1a*

From the above account and the figures, it will be seen that the original type of venation for the Order, as preserved in the Homoneura, closely resembled that of the primitive types amongst the Trichoptera. From these the Lepidopterous venation differs chiefly in having no free M_4 in forewing, no wing-spot, and fewer cross-veins and veinlets.

The methods of coupling the wings in flight in the Lepidoptera are of great interest. Originally (Micropterygoidea) there was a *jugal lobe* or *fibula* (fig. Z18, *jl*) at the base of the forewing, which overlapped the costal margin of the hind, as in many Trichoptera (fig. Y1). As a specialization from this, we find the true *jugum* of the Hepialoidea, a finger-like process generally supposed to pass *under*

.ta of the hindwing (Z6, A) which is thus gripped between the .m itself and the hind border of the forewing near its base*. In ie Heteroneura there is an entirely different line of specialization,

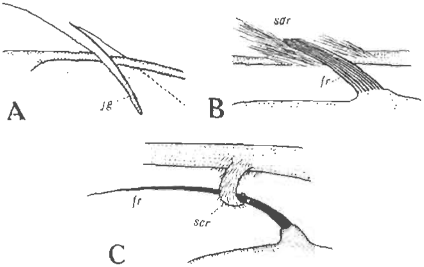


FIG. Z6. Wing-coupling apparatus of Lepidoptera; A. in *Charagia eximia* Sc., fam. Hepialidae (jugate type); B. in *Hippotion scrofa* Bd., female, fam. Sphingidae, showing frenulum of eight strong bristles, and subdorsal retinaculum formed of hairs; C. in male of same, showing frenulum of a single, strong bristle, and subcostal retinaculum in the form of a chitinous hasp (B and C, frenate type); *fr*, frenulum; *jg*, jugum; *scr*, subcostal retinaculum; *sdr*, subdorsal retinaculum. [*R. J. T. del.*

known as *frenate coupling*, formed by the development of a set of stiff hairs or bristles, called the *frenulum*, from the humeral lobe at the base of the costa of the hindwing. In most females these bristles remain distinct (fig. Z6, B); in males they all fuse into a single, stiff bristle of greater length (fig. Z6, C). The frenulum passes beneath the forewing and is engaged by a small catch or *retinaculum*; this is a set of stiff hairs curved forwards from below Cu_1 (*subdorsal retinaculum*, in both sexes, *sdr*) and also, in males, with very few exceptions, a strongly curved, chitinous lobe or process curving downwards from *Sc* (*subcostal retinaculum, scr*). Finally, in the Butterflies and some other specialized groups, the frenulum and retinaculum are lost, and the hindwing is held in position by upward pressure against the stiff dorsal portion of the forewing (*amplexiform coupling*).

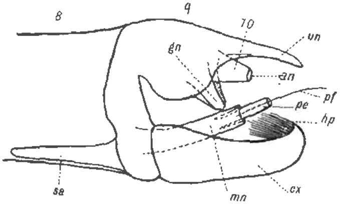


FIG. Z7. Diagrammatic representation of terminal appendages of a male Lepidopteron, lateral view; *an*, anus; *cx*, gonocoxite (clasper or valve); *gn*, gnathos; *hp*, harpe; *mn*, manica; *pe*, penis; *pf*, penisfilum; *sa*, saccus; *un*, uncus. [*R. J. T. del.*

*Recent researches by Mr. A. Philpott indicate that this classical view of the method of functioning of the Hepialid jugum is incorrect.

Abdomen usually more or less cylindrical or fusiform, and generally more or less completely covered with hairs or scales. Ten segments are present, but in the females segs. 9-10 are completely

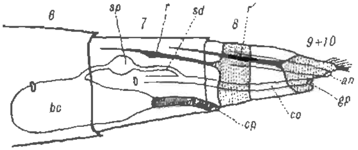


FIG. Z8. Diagrammatic representation of terminal abdominal segments of a female Lepidopteron, lateral view, showing internal structures: *an*, anus; *bc* bursa copulatrix; *co*, common oviduct; *cp*, copulatory aperture; *gp*, gonopore; *r*, outer rod; *r'*, inner rod, *sd*, seminal duct; *sp*, spermatheca.
[*R. J. T. del.*

fused together (except in Micropterygidae); the sternite of seg. 1 is always reduced, often to a pair of chitinous hooks which are movably attached to the thoracic metasternum. In the males (fig. Z7), seg. 9 is completely chitinized, forming the genital segment or *tegumen*; its tergite is produced caudad into a process known as the *uncus* (*un*), which serves as a protection for the small tenth segment or *proctiger* carrying the anus (*an*). Beneath the anus there is frequently developed a peculiar structure called the *gnathos* (*gn*), in the form of a chitinous arch projecting obliquely downwards and movably attached by a membranous base to the underside of the ninth tergite. The ninth sternite is called the *vinculum* and is usually produced basad into a median process called the *saccus* (*sa*); distally it carries the two well-developed *gonocoxites*, generally called *claspers* or *valves** (*cx*); sometimes there are specialized growths of stiff hairs or bristles known as the *harpes** (*hp*) arising from the inner distal surface of the claspers and directed inwards and basad. In the higher families a pair of surgonopods, called the *socii*, are developed as hairy, membranous processes, one on either side of the anus. A small chitinous plate, called the *juxta*, is often present between the bases of the claspers and helps to support the aedeagus. The *penis* (*pe*) arises from between the bases of the claspers, and is a chitinized, tubular organ which can be retracted in a membranous sheath or *manica* (*mn*); usually it carries a fine terminal thread or *penisfilum* (*pf*), at the end of which the ejaculatory duct opens. In the females (fig. Z8), segs. 8-10 are more or less telescopic and separated by wide areas of membrane; segs. 9-10 are fused together, usually forming a complete, chitinous tube with the anus (*an*) opening at its end and the true gonopore (*gp*) immediately beneath it. The gonopore is used for copulation as well as ovipositing only in the most archaic groups; in the Micropterygidae, it opens into the rectum close to the anus, so that a kind of terminal *cloaca* is formed. In the higher groups, a secondary opening is developed for copulation in the membrane between segs. 7-8 or at base of eighth sternite, the original gonopore being retained for oviposition only. This new opening, the *copulatory aperture* (*cp*) leads by way of a chitinous duct into a large

*This is the British usage, following Burmeister; recent American authors apply the term "harpes" to the claspers.

bursa copulatrix (*bc*) for holding the sperms; from it, a tiny *seminal duct* (*sd*) is given off, leading into a small *spermatheca* (*sp*), not always present, and continuing thence into the *common oviduct* (*co*) which opens at the true gonopore. This complex arrangement allows of the sperms being retained fresh for many days after pairing, and also admits of the act of oviposition being carried on over a long period, the sperms being passed little by little into the spermatheca, whence they can reach and fertilize the eggs as they pass down the oviduct. The telescopic movement of the segments is carried out by strong muscles attached to two pairs of elongated rods (absent in Micropterygidae) developed internally and basad from tergites 8-9. The *outer rods* (*r*) are developed from the eighth tergite, the *inner rods* (*r'*) from the ninth; these latter often assist in the actual process of oviposition. *Spiracles* are present on segs. 1-7 only; those of seg. 8 are present but functionless in the pupa, obsolete in the imago.

Life History. The *eggs* are of varying shapes but never of the primitive, elongate, oval type; those of the Homoneura are spherical or nearly so, as are also those of the Cossidae. In the higher groups the eggs are often of peculiar shapes and have the chorion ribbed or sculptured in a more or less intricate manner (fig. A18, F). Most forms

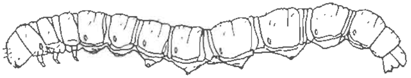


FIG. Z9. Larva of *Leto stacyi* Scott. Fam. Hepialidae; lateral view. Length 5 inches. [*A. Tonnoir del.*

FIG. Z10. Larva of *Tortrix excessana* Walk. Fam. Tortricidae, lateral view. Length 20 mm. [*R. J. T. del.*

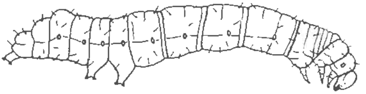


FIG. Z11. Larva of *Plusia chalcites* Esper. Fam. Noctuidae, subfam. Plusiinae; lateral view. Length 30 mm. [*R. J. T. del.*

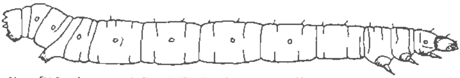


FIG. Z12. Larva of *Boarmia productata* Walk. Fam. Boarmiidae; lateral view. Length 40 mm. [*R. J. T. del.*

affix their eggs either singly or in masses to the food-plant by means of a sticky secretion; others spray them about freely while flying, or drop them on the ground, or insert them into special places by means of the long, tubular ovipositor.

The *larva*, or *caterpillar* (figs. Z9-Z12) is usually an elongate, cylin-

drical grub with a soft integument; the hard head is furnished with *strong, biting mandibles, very short antennae, and normally a set of* six separate ommatidia on each side, representing the compound eyes

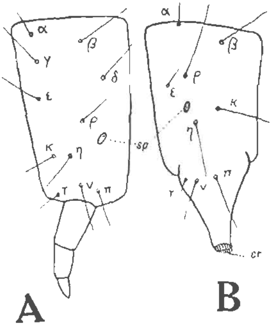


FIG. Z13. Chaetotaxy of first instar of larva of *Perissectis australasiae* Don Fam. Hepialidae. A, prothorax; B, third abdominal segment; *cr*, crochets of proleg; *sp*, spiracle. [*R. J. T. del.*

of the imago. The labium-hypopharynx is much reduced and carries the slender, pointed *spinneret*, from which the copious secretion of the immense silk-glands is spun as fine silk. The prothorax sometimes bears a more or less strongly chitinized dorsal shield, the *prothoracic shield*. The three pairs of thoracic legs are generally present but very short. The abdomen consists of ten segments, of which the last sometimes carries a more or less strongly chitinized plate, the *suranal plate*. Normally there are five pairs of short, stumpy abdominal legs, called *claspers* or *prolegs*, placed on segs. 3, 4, 5, 6 and 10 respectively. In the "semi-loopers" (fam. Noctuidae, fig. Z11) only three pairs are fully developed, viz., those on segs. 5, 6 and 10. In the "loopers" or "Geometers" (Section Geometrites of the Notodontoidea, fig. Z12), only those of segs. 6 and 10 are fully developed. In the Notodontidae the anal claspers (those on seg. 10) are often non-functional and may be peculiarly modified, as in the genus *Cerura*. In leaf-mining or tunneling forms all the prolegs and even the thoracic legs may be absent. There are normally nine pairs of *spiracles*, viz., one pair on the prothorax and on each of segs. 1-8 of the abdomen. Nearly all Lepidopterous caterpillars feed on vegetable matter, mostly on the leaves of plants. A considerable number bore into stems and trunks, or tunnel in the ground amongst roots. Only a few are predaceous, attacking plant- and leaf-hoppers, aphids and scale-insects, while a few others eat débris or animal matter. One or two genera of Pyraustidae have aquatic larvae which live in portable cases like those of Caddis-flies and develop external gill-filaments. The number of larval instars is generally four, (rarely three only, or from five to as many as nine).

The study of the morphology of Lepidopterous larvae is an

important subject owing to the great economic damage done by them. The most reliable characters are the following:—

1. *Ommatidia*:—The typical caterpillar has six ommatidia on each side of the head, four latero-dorsal and two latero-ventral. The larvae of Gracilariidae and some Tineidae have only one pair. Those of Micropterygidae have a pair of compound eyes, each containing five conjoined facets.

2. *Prolegs*:—In the young larvae of Micropterygidae there are segmented abdominal legs, like thoracic legs but smaller; they become obsolescent with growth. Typical caterpillars have each proleg in the form of a stump ending in a flattened end or *planta* furnished with numerous hooks or *crochets*. The more primitive forms, which feed concealed, have the crochets arranged in complete *circlets*; in the higher forms, only the inner part of the circlets is developed, forming a *mesoseries*, suitable for forms feeding externally on leaves. The crochets may be all of the same length (*uniordinal*) or long and short alternating (*biordinal*).

3. *Chaetotaxy*, or arrangement of the setae or hairs on the segments:—Apart from the Micropterygid larva, whose chaetotaxy does not fit into the general scheme, a single type of chaetotaxy runs through the whole Order. Fracker has designated all the primitive simple setae by Greek letters; his notation is shown in fig. Z13.

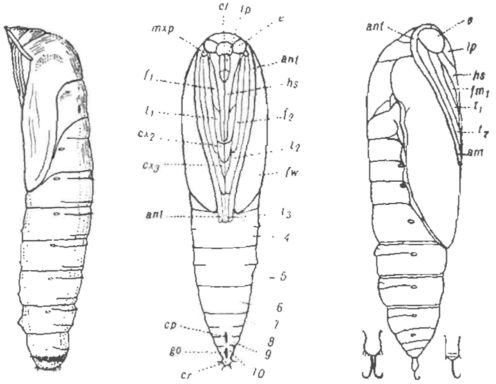
The twelve *primary setae*, i.e. those present in the first instar, are α, β, γ, δ, ε, ρ, κ, η, ν, π, τ, σ. Four additional *subprimary setae*, θ, μ, ω, φ, may appear at the second instar; θ on meso- and metathorax of Hepialoidea and Heteroneura, and on abdomen of Hepialoidea only; μ on abdomen of Heteroneura only; ω and φ less frequently. Each seta is primitively borne on a small papilla, which may become enlarged into a flat plate or *pinaculum*, or the seta may be raised up on a small tubercle, called a *chalaza*. In the higher groups, a great change takes place after the first instar; the colour and appearance of the larva may change entirely, and, at the same time, each originally single seta may be replaced by a tuft of fine setae borne on a wart (*verruca*) or by a strong, thorny process with spiny setae on it (*scolus*). Such specialized larvae occur in the higher superfamilies from Psychoidea upwards

The *pupa*, sometimes termed a *chrysalis* in this Order, is of one of the three following types:—

1. A *pupa libera*, with soft integument, functional mandibles, and all parts free; this is found only in the Micropterygoidea.

2. A *pupa incompleta*, found in the lower superfamilies from Hepialoidea up to Psychoidea; it has a thicker integument, no mandibles, and the appendages are partially free and completely sheathed; it is mobile, and normally leaves its cocoon or burrow before metamorphosis. Seg. 7 of abdomen is freely movable in the male but not in the female; there are also several other movable segments, usually 3-6 or 4-6 in both sexes. Except in the Pterophoroidea, the cremaster (see below) is absent or of very simple form.

3. A *pupa obtecta*, commonly called a *chrysalis*, found in all



Figs. Z14-16, from left to right:—

Fig. Z14. Pupa of *Leto stacyi* Sc. Fam. Hepialidae, lateral view. Length $4\frac{1}{2}$ inches. [*A. Tonnoir del.*

Fig. Z15. Pupa of *Tortrix excessana* Walk., female. Fam. Tortricidae; ventral view. Length 12 mm.; *ant*, antennae; *cp*, copulatory aperture; *cl*, *clypeus*; *cr*, *cremaster*; cx_1, cx_2, cx_3, fore, middle and hind coxae; *e*, eye; f_1, f_2, fore and middle femora; *fw*, forewing; *go*, gonopore; *hs*, haustellum; *lp*, labial palp; *mxp*, maxillary palp; t_1, t_2, t_3, fore, middle and hind tibio-tarsi; *4-10*, abdominal segments. [*R. J. T. del.*

Fig. Z16. Pupa of *Plusia chalcites* Esper, female. Fam. Noctuidae; lateral view. Length 20 mm. Lettering as in fig. Z15, except fm_1, fore femur. Below, to right, lateral view of cremaster, enlarged; to left, dorsal view of same, enlarged. [*R. J. T. del.*

the higher groups from Lasiocampoidea to Butterflies; this has a hard, smooth, rounded and externally solid integument, no mandibles, and the appendages are completely soldered down and covered over by external plates only; it is not mobile, but remains in a fixed position, usually attached to a silken pad by means of the *cremaster*, which is a specialized process formed from the suranal plate of the larva, and, like them, carrying numerous hooks. The eyes are divided into a smooth portion, the *glazed eye* (fig. Z37, *ge*) and a sculptured portion called the *sculptured eye* (fig. Z37, *se*). The free parts of the abdomen are at the most segs. 5-6 in both sexes.

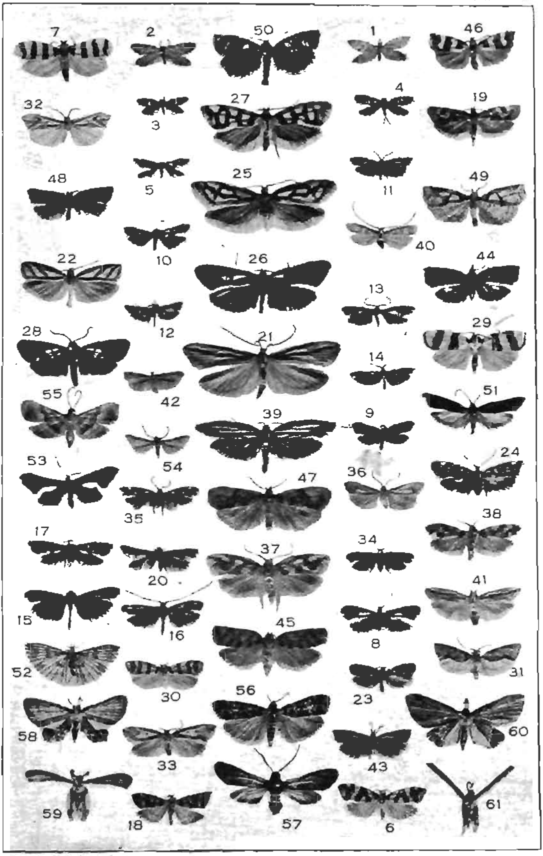
In all Lepidopterous pupae the original tracheation of the wings is completely preserved and furnishes data of great value in tracing the homologies and evolution of the imaginal wing-veins; in this respect the Lepidoptera are much more primitive than the Mecoptera and Trichoptera, the former having lost this tracheation partially and the latter completely. Many Lepidopterous pupae are enclosed in a silken *cocoon* spun from the mouth of the larva; some lie hidden in burrows closed with a silken wad; others are attached to a silken pad,

Plate 28

AUSTRALIAN AND NEW ZEALAND LEPIDOPTERA

All figures natural size

1. *Sabatinca incongruella* Walk. (Fam. Micropterygidae), N.Z.
2. *Sabatinca calliarcha* Meyr. (Fam. Micropterygidae), N.Z.
3. *Sabatinca ianthina* Philp. (Fam. Micropterygidae), N.Z.
4. *Micropardalis doroxena* Meyr. (Fam. Micropterygidae), N.Z.
5. *Mnesarchaea hamadelpha* Meyr. (Fam. Mnesarchaeidae), N.Z.
6. *Narycia trifasciana* Walk. (Fam. Tineidae), Aus.
7. *Iphierga euphragma* Meyr. (Fam. Tineidae), Aus.
8. *Tinea xystidophora* Meyr. (Fam. Tineidae), Aus.
9. *Taleporia scotinopis* Meyr. (Fam. Tineidae), Aus.
10. *Sagephora phortigella* Meyr. (Fam. Tineidae), N.Z.
11. *Orthenches glyptarcha* Meyr. (Fam. Plutellidae), N.Z.
12. *Parectopa ida* Meyr. (Fam. Gracilariidae), Aus.
13. *Parectopa zorionella* Huds. (Fam. Gracilariidae), N.Z.
14. *Gracilaria chrysitis* Feld. (Fam. Gracilariidae), N.Z.
15. *Amphithera heteroleuca* Turn. (Fam. Amphitheridae), male, Aus.
16. *Amphithera heteroleuca* Turn. (Fam. Amphitheridae), female, Aus.
17. *Glyphipteryx zelota* Meyr. (Fam. Glyphipterygidae), N.Z.
18. *Choreutis lampadias* Meyr. (Fam. Glyphipterygidae), Aus.
19. *Heliostibes electrica* Meyr. (Fam. Glyphipterygidae), N.Z.
20. *Stathmopoda callichrysa* Low. (Fam. Heliodinidae), Aus.
21. *Cryptolechia radiosella* Walk. (Fam. Oecophoridae), Aus.
22. *Thudaca obliquella* Walk. (Fam. Oecophoridae), Aus.
23. *Eulechria triferella* Walk. (Fam. Oecophoridae), Aus.
24. *Tisobarica pyrrhella* Turn. (Fam. Oecophoridae), Aus.
25. *Philobota sophia* Turn. (Fam. Oecophoridae), Aus.
26. *Philobota arabella* Newm. (Fam. Oecophoridae), Aus.
27. *Chrysonoma argutella* Zell. (Fam. Oecophoridae), Aus.
28. *Aristeis hepialella* Walk. (Fam. Oecophoridae), Aus.
29. *Zonopetala divisella* Walk. (Fam. Oecophoridae), Aus.
30. *Eriodyta contentella* Walk. (Fam. Oecophoridae), Aus.
31. *Lepidotarsa chrysetythra* Turn. (Fam. Oecophoridae), Aus.
32. *Eclecta aurorella* Meyr. (Fam. Oecophoridae), Aus.
33. *Borkhausenia plagiatella* Walk. (Fam. Oecophoridae), N.Z.
34. *Borkhausenia chrysogramma* Meyr. (Fam. Oecophoridae), N.Z.
35. *Macrobathra argonota* Meyr. (Fam. Oecophoridae), Aus.
36. *Gymnobathra flavidella* Walk. (Fam. Oecophoridae), N.Z.
37. *Plectophila thrasycosma* Meyr. (Fam. Xyloryctidae), Aus.
38. *Lichenaula melanoleuca* Turn. (Fam. Xyloryctidae), Aus.
39. *Catoryctis eugramma* Meyr. (Fam. Xyloryctidae), Aus.
40. *Crocanthes sidonia* Meyr. (Fam. Gelechiidae), male, Aus.
41. *Protolechia obeliscota* Meyr. (Fam. Gelechiidae), Aus.
42. *Elachista thallophora* Meyr. (Fam. Elachistidae), N.Z.
43. *Acroclita trimerodana* Meyr. (Fam. Eucosmidae), Aus.
44. *Argyroploce miltographa* Meyr. (Fam. Eucosmidae), Aus.
45. *Tortrix desmotana* Meyr. (Fam. Tortricidae), Aus.
46. *Tortrix tasmaniana* Walk. (Fam. Tortricidae), Aus.
47. *Tortrix pictoriana* Feld. (Fam. Tortricidae), N.Z.
48. *Capua debiliana* Walk. (Fam. Tortricidae), Aus.
49. *Harmologa amplexana* Zell. (Fam. Tortricidae), N.Z.
50. *Harmologa sanguinea* Philp. (Fam. Tortricidae), N.Z.
51. *Bondia caseata* Meyr. (Fam. Carposinidae), male, Aus.
52. *Orneodes phricodes* Meyr. (Fam. Orneodidae), Aus.
53. *Euthesaura carbonaria* Turn. (Fam. Tineodidae), Aus.
54. *Oxychirota paradoxa* Meyr. (Fam. Oxychirotidae), Aus.
55. *Addaea pusilla* Butl. (Fam. Thyrididae), Aus.
56. *Scoparia exhibitalis* Walk. (Fam. Pyraustidae), Aus.
57. *Hestiochora tricolor* Walk. (Fam. Zygaenidae), Aus.
58. *Balantiucha decorata* Warr. (Fam. Epiplemidae), female, Aus.
59. *Balantiucha decorata* Warr. (Fam. Epiplemidae), female, in position of rest.
60. *Lobogethes interrupta* Warr. (Fam. Epiplemidae), male, Aus.
61. *Lobogethes interrupta* Warr. (Fam. Epiplemidae), male, in position of rest.



W. C. Davies photo.

AUSTRALIAN AND NEW ZEALAND LEPIDOPTERA

or held in position by a silken girdle; others again, lie free on the ground or buried in the earth.

Distribution. The Order is well represented by nearly 8,000 species in Australia and 1,200 in New Zealand. But, whereas the Australian fauna is rich in almost every family from the lowest to the highest, that of New Zealand is remarkable for the almost complete absence of most of the higher groups of Moths and for its exceedingly poor Butterfly fauna. There are no Cossoidea, Castnioidea, Lasiocampoidea, Uranoidea or Bombycoidea in New Zealand, and many families in other groups are also absent; in the Butterflies, New Zealand has representatives of only two families, Nymphalidae and Lycaenidae. The Palaeosetidae, Anomosetidae and Cyclotornidae are peculiar to Australia, the Mnesarchaeidae to New Zealand. The Copromorphidae are confined to Australia and New Zealand, the Anthelidae to Australia and Papua, the Oxychirotidae to Australia and Christmas Island, south of Java. The Micropterygidae are widespread, but have their headquarters in New Zealand, and occur sparingly in Australia also. The known Tineoidea already comprise about one half of the Australian species, the most abundant families being the Oecophoridae (1515 species), Gelechiidae (438), Tineidae (394), Elachistidae (328), Tortricidae (299), and Xyloryctidae (269). There are also 884 Noctuidae, 456 Pyraustidae, 292 Boarmiidae, 201 Larentiidae, 194 Phycitidae and 168 Arctiidae. In New Zealand the largest number of species occur in the Larentiidae (181), followed by the Oecophoridae (149), Noctuidae (120), Pyraustidae (118), Tortricidae (102), Crambidae (79), Tineidae (97) and Glyphipterygidae (53).

It is of special interest to note that Australia possesses the finest Hepialid in the world (*Leto stacyi* Sc.), the most beautiful Pyraloid (*Hypsidea erythropsalis* Roth.), the most remarkable Skipper Butterfly (*Euschemon rafflesia* W.S.M., in which the male has a frenulum), the heaviest-bodied moth (*Xyleutes boisduvali* H. Sch., fam. Cossidae) and the moth with the greatest wing-area (*Coscinocera hercules* Misk., fam. Saturniidae).

Economics. This Order is on the whole harmful to man, the larvae of Lepidoptera, with few exceptions, being vegetable feeders, and many of them doing great injury to his crops, grasses, fruit-trees and timber. The most important of these are the Cutworms and Army-worms (Noctuidae), subterranean grass-grubs (Hepialidae), various stem and wood borers (Hepialidae, Cossidae, Xyloryctidae, Aegeriidae), numerous leaf-feeders such as the leaf-rollers (Tortricidae), gregarious leaf-feeders (Lymantriidae), etc., and fruit-eaters (Codling-moth, Tomato-grub, etc.). A few also attack clothes, furs and leather (Tineidae), while several widely spread Pyraloids attack grain and flour. Of beneficial forms there are few only, viz. the Silk-worms (Bombycidae and Saturniidae), the peculiar Epipyropidae, whose larvae feed on plant- and leaf-hoppers, and the genera predaceous on aphids and scale-insects, viz. *Stathmopoda* (Heliodinidae) and *Catoblemma* (Noctuidae).

Fossil History. No true fossil Lepidoptera are known before the beginning of the Tertiary Epoch,* though it is certain, on morphological grounds alone, that the archaic Micropterygidae, or forms

*The Jurassic Palaeontinidae from Bavaria, considered by Handlirsch to be allied to the Limacodidae, have been shown to be Homoptera allied to the Cicadidae.

CLASSIFICATION

SCHEME OF CLASSIFICATION AND CENSUS OF SPECIES

Order LEPIDOPTERA 7942 (1190)

Suborder HOMONEURA 40 (42)

I. MICROPTERYGOIDEA 2 (22)
- 1 MICROPTERYGIDAE 2 (17)
- 2 MNESARCHAEIDAE 0 (5)

II. HEPIALOIDEA 38 (20)
- 3 HEPIALIDAE 36 (20)
- 4 ANOMOSETIDAE 1 (0)
- 5. PALAEOSETIDAE 1 (0)

Suborder HETERONEURA 7902 (1148)

Division *HETEROCERA* 7568 (1132)

III. COSSOIDEA 36 (0)
- 6. COSSIDAE 36 (0)

IV. CASTNIOIDEA 25 (0)
- 7. CASTNIIDAE 25 (0)

V. TINEOIDEA 3963 (537)
- 8. TINEIDAE 394 (97)
- 9. PLUTELLIDAE 25 (24)
- 10. GRACILARIIDAE 138 (18)
- 11. EPIPYROPIDAE 8 (0)
- 12. CYCLOTORNIDAE 5 (0)
- 13. AMPHITHERIDAE 4 (0)
- 14. HYPONOMEUTIDAE 100 (3)
- 15. GLYPHIPTERYGIDAE 116 (53)
- 16. HELIODINIDAE 94 (17)
- 17. COPROMORPHIDAE 7 (3)
- 18. AEGERIIDAE 15 (0)
- 19. OECOPHORIDAE 1515 (149)
- 20. XYLORYCTIDAE 269 (2)
- 21. GELECHIIDAE 438 (22)
- 22. ELACHISTIDAE 328 (24)
- 23. CHLIDANOTIDAE 3 (0)
- 24. EUCOSMIDAE 165 (11)
- 25. TORTRICIDAE 299 (102)
- 26. PHALONIIDAE 10 (0)
- 27. CARPOSINIDAE 30 (12)

VI. PTEROPHOROIDEA 36 (19)
- 28. PTEROPHORIDAE 30 (19)
- 29. ORNEODIDAE 6 (0)

VII. PYRALOIDEA 1024 (209)
- 30. TINEODIDAE 9 (0)
- 31. OXYCHIROTIDAE 2 (0)
- 32. THYRIDIDAE 45 (1)
- 33. PYRAUSTIDAE 456 (118)
- 34. PYRALIDAE 131 (3)
- 35. SCHOENOBIIDAE 23 (0)
- 36. CRAMBIDAE 112 (79)
- 37. GALLERIIDAE 52 (2)
- 38. PHYCITIDAE 194 (6)

VIII. PSYCHOIDEA 76 (2)
- 39. PSYCHIDAE 25 (2)
- 40. ZYGAENIDAE 16 (0)
- 41. LIMACODIDAE 35 (0)

IX. LASIOCAMPOIDEA 46 (0)
- 42. LASIOCAMPIDAE 46 (0)

X. NOCTUOIDEA 1275 (126)
- 43. ANTHELIDAE 52 (0)
- 44. DREPANIDAE 3 (0)
- 45. HYPSIDAE 14 (1)
- 46. LYMANTRIIDAE 60 (0)
- 47. NOCTUIDAE 884 (120)
- 48. NOLIDAE 42 (1)
- 49. ARCTIIDAE 168 (4)
- 50. SYNTOMIDAE 52 (0)

XI. URANIOIDEA 33 (0)
- 51. EPIPLEMIDAE 22 (0)
- 52. URANIIDAE 11 (0)

XII. NOTODONTOIDEA 1038 (239)
- 53. NOTODONTIDAE 67 (0)
- 54. SPHINGIDAE 55 (2)
- 55. OENOCHROMATIDAE 174 (11)
- 56. BOARMIIDAE 292 (44)
- 57. GEOMETRIDAE 137 (0)
- 58. STERRHIDAE 112 (1)
- 59. LARENTIIDAE 201 (181)

XIII. BOMBYCOIDEA 16 (0)
- 60. BOMBYCIDAE 7 (0)
- 61. SATURNIIDAE 9 (0)

Division *RHOPALOCERA* 334 (16)

XIV. HESPERIOIDEA 92 (0)
- 62. HESPERIIDAE 92 (0)

XV. PAPILIONOIDEA 17 (0)
- 63. PAPILIONIDAE 17 (0)

XVI. NYMPHALOIDEA 225 (16)
- 64. NYMPHALIDAE 80 (11)
- 65. PIERIDAE 30 (0)
- 66. LYCAENIDAE 115 (5)

closely resembling them, must be at least as old geologically as the Trichoptera, and must therefore have existed in the Lias. Butterflies have been found both in the Eocene and Oligocene of N. America, and some small moths, including one Micropterygoid type, in Baltic Amber (*Oligocene*). No fossil Lepidoptera are known from Australia. The Heteroneurous Lepidoptera appear to have been the last of the great groups of Insects to be evolved, and probably arose in the Cretaceous with the evolution of the Flowering Plants.

The characters used in classification are the structure of the mouth-parts, the details of the wing-venation, the nature of the wing-coupling, the form of the antennae and the presence or absence of tibial spurs. The Order is primarily divisible into two Suborders of very unequal extent, as follows:—

Venation of fore and hindwing closely similar, i.e., *Sc* and R_1 separate, and *Rs* with four, or rarely, three, branches in both wings. Suborder HOMONEURA

Venation of fore and hindwing markedly different, i.e., hindwing with *Sc* and R_1 fused distally into a single vein, and *Rs* simple. Suborder HETERONEURA

Suborder HOMONEURA

This is a small Suborder containing only seven known families and totalling less than 0.5 per cent of the whole Order at the present day The media is almost always complete, the cubito-median Y-vein generally present. There are two superfamilies, distinguished as follows:—

Very small moths, expanding 12 mm. or less, having the principal fork of *M* at or beyond half-way, and without a closed median cell; wings coupled by means of a small jugal lobe or fibula at base of forewing. I. MICROPTERYGOIDEA

Medium to very large moths, expanding from 15 mm. up to nine inches, having the principal fork of *M* close to base, and the long, narrow median cell closed distally by *im*; wings coupled by means of a true jugum at base of forewing. II. HEPIALOIDEA

Superfamily I. MICROPTERYGOIDEA

This group contains only three families, Micropterygidae, Eriocraniidae and

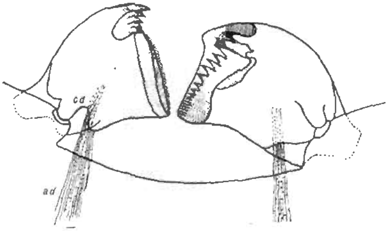


FIG. Z17. Mandibles of *Sabatinca incongruella* Walk. Fam. Micropterygidae (x 200); *ad*, adductor muscle; *cd*, condyle. [*R. J. T. del.*

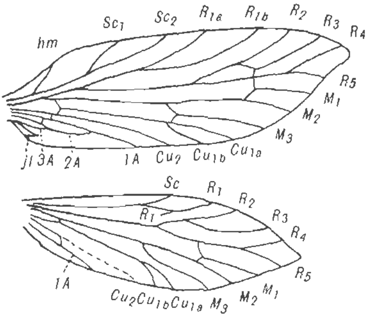


FIG. Z18. Wing-venation of *Sabatinca incongruella* Walk. Lettering as in fig. A8, p. 22; except *jl*, jugal lobe (*cf.* fig. Y1, A). [*A. Philpott del.*

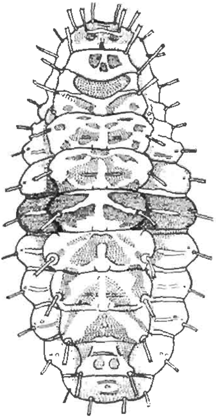


FIG. Z19. Larva of *Sabatinca barbarica* Philp., full-fed; dorsal view, head retracted. Length 4 mm. [*R. J. T. del.*

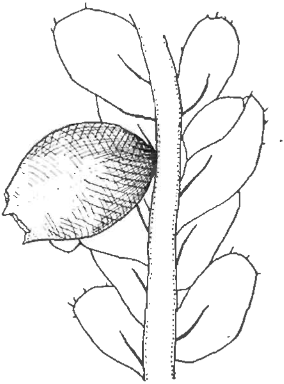


FIG. Z20. Cocoon of *Sabatinca incongruella* Walk., attached to stem of liverwort. Length 3 mm. [*R. J. T. del.*

Mnesarchaeidae; of these the Eriocraniidae are not found in Australia or New Zealand, but are included in the Key:—

1. Mandibles present, functional and toothed; lacinia and galea present, but latter not elongated; forewing with *ir* present, closing the areole; middle tibiae without spurs. Fam. 1. MICROPTERYGIDAE
   Mandibles either absent, or non-functional and not toothed; lacinia absent; galeae elongated; forewing with *ir* absent; middle tibiae with one or two spurs. 2

2. Mandibles present as non-functional lobes, not toothed; maxillae with long, 5-segmented palpi and short haustellum; wings with R_1 forked distally. [Fam. ERIOCRANIIDAE]
Mandibles absent; maxillae with minute, 3-segmented palpi and well-formed haustellum; wings with R_1 simple Fam. 2. MNESARCHAEIDAE

Family 1. **Micropterygidae** [Aus. 2, N.Z. 17]. These tiny moths are by far the most primitive Lepidoptera known to exist. Besides the characters given in the Key, they are peculiar in having the mouth-parts specialized for grinding pollen or spores, the small but powerful mandibles (fig. Z17) working in conjunctions with a peculiar triturating basket, formed from the hypopharynx, and special brushes of hairs developed on the epipharynx; the labium has no ligula, but the rather short, 3-segmented palpi have a process on the basal segment. Tibial spurs 0-0-4. The venation comes close to that of certain archaic types of Trichoptera, and the anal veins in both are closely similar; *Rs* has four branches, arranged dichotomically; *M* has only three free branches in both wings. The scales are of primitive, oval form, without cross-strioles or pigment (fig. Z4, A); the wing-membrane being pigmented, the wings appear metallic. The males have primitive, exserted, copulatory appendages, but the females are remarkably specialized in having the common oviduct opening into the rectum, so that a single terminal opening, or cloaca, serves both for pairing, oviposition and defaecation. Most of the species have, in both sexes, a pair of glandular organs opening on to the sides of the fifth abdominal segment, and considered by Philpott to be scent-organs. New Zealand is the headquarters of the family, possessing 16 species of *Sabatinca* and *Micropardalis*. They are very small moths, expanding from 6 to 12 mm. Their wings are held in a high, roof-like manner over the abdomen, and they are capable of springing into the air like caddis-flies. The commonest New Zealand species are *S. incongruella* Walk. (pl. 28, fig. 1) and *S. chrysargyra* Meyr., with dark fawn-coloured forewings. *S. aurella* Huds. (pl. 38, fig. 1) has bright bronze-gold forewings. *S. calliarcha* Meyr. (pl. 28, fig. 2) is the largest species, expanding 11-12 mm. *S. ianthina* Philp. (pl. 28, fig. 3) has purple forewings crossed by a white band. *Micropardalis doroxena* Meyr. (pl. 28, fig. 4) is a handsome species with terminal black blotches enclosing white spots on forewings. This genus differs from *Sabatinca* in its broader wings and in having the fork of R_{4+5} sessile on the areole. Two small species of *Sabatinca*, *S. calliplaca* Meyr. and *S. sterops* Turn., occur in Queensland.

The larvae are extraordinary creatures, superficially resembling those of Limacodidae, but structurally more like the larvae of Mecoptera; the head is retractile, with prominent, 3-segmented antennae and a pair of true compound eyes of five conjoined facets each; the young larva has eight pairs of segmented abdominal legs, which become obsolescent during growth. It feeds on liverwort, and spins a tough, oval cocoon in which it changes to a soft *pupa libera* having well-formed and normally placed mandibles.*

Family 2. **Mnesarchaeidae** [Aus. 0, N.Z. 5]. A small family confined to New Zealand, and with only one genus, *Mnesarchaea*. These moths resemble small Plutellidae, but have a minute jugal lobe, no frenulum, and *Rs* 3-branched in both wings; tibial spurs 0-2-4. Life history quite unknown. *M. hamadelpha* Meyr. (pl. 28, fig. 5) and *M. loxoscia* Meyr. have black and white forewings. *M. paracosma* Meyr. is a smaller, dull brownish species.

Superfamily II. HEPIALOIDEA

This group includes four families, of which one, the Hepialidae, is world-wide, two are confined to Australia, and a fourth, the Prototheoridae, is only found in South Africa; they may be distinguished as follows:—

1. Both main branches of *M* present within the cell. 2
Only the lower main branch, M_{3+4}, present within the cell. 3

2. M_4 well developed, oblique, forming a Y-vein with Cu_{1a}; fork of R_{2+3} well developed; forewing with *Sc* not distally forked (except in the American genus *Sthenopis*); hindwing with two anal veins.
Fam. 3. HEPIALIDAE
M_4 tranverse, little more than a cross-vein; fork of R_{2+3} very small, apical; forewing with *Sc* distally forked; hindwing with one short anal vein, far removed from Cu_2.
[Fam. PROTOTHEORIDAE]

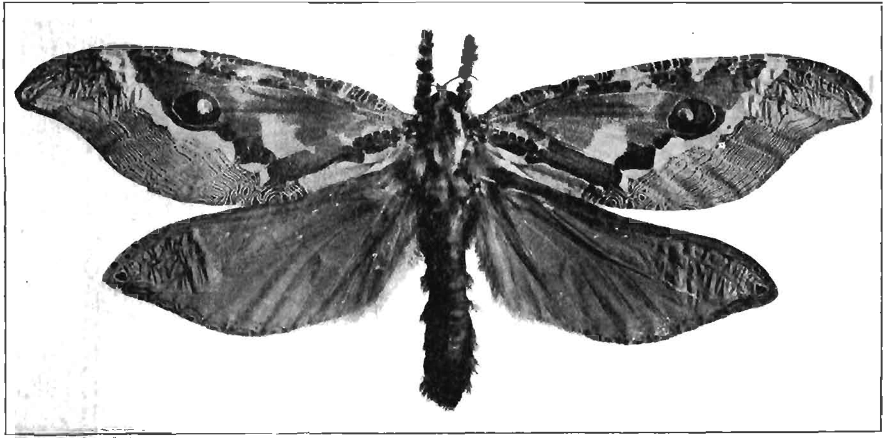
*The larvae of Eriocraniidae are legless leaf-miners; their pupae have hypertrophied mandibles, standing out transversely in line with one another.

3. Tibial spurs present. Fam. 4. ANOMOSETIDAE
Tibial spurs absent. Fam. 5. PALAEOSETIDAE

Family 3. **Hepialidae** (Swift Moths) [Aus. 36, N.Z. 20]. Head small, with short antennae having ventral surface differing from dorsal; mouth-parts vestigial, except only the labial palpi, which are well formed; fore- and hind-gut vestigial, mid-gut entirely absent, so that the imago can take no food. Venation (fig. Z1) very primitive, but Cu_2 only partially formed in forewing, and sometimes also in hind. Veinlet *hm* and cross-vein *cu-a* present in forewing. Jugum well formed (fig. Z1, *jg*). Larva elongate, cylindrical, living in tunnels. Pupa cylindrical, of incomplete type, with dorsal and ventral ridges of spines; free abdominal segments 3-7 in male, 3-6 in female; spiracles of first abdominal segment invisible (fig. Z14).

This family includes some of the largest and handsomest moths known. They fly very rapidly, coming freely to light. The female has the peculiar habit of twirling her abdomen round and round, spraying her spherical eggs far and wide. The genus *Porina* contains all but one of the New Zealand species and a number of Australian and Patagonian species also, thus having a definite Antarctic distribution. The larvae are typical "subterranean grass-grubs", tunnelling amongst grass-roots and doing much damage to pastures and lawns. The larvae of this genus and of *Pielus* are attacked by the fungi of the genus *Cordyceps*, which transforms each into a "vegetable caterpillar" having the slender, clubbed fungus growing vertically from its head. Of the New Zealand species the most beautiful is the rare and intricately marked *Porina characterifera* Walk. (pl. 31, fig. 1), while the commonest are the two smaller species *P. umbraculata* Gn. (pl. 31, fig. 2) and *P. signata* Walk. *P. fuscomaculata* Walk. and *P. rufescens* Walk. are common Australian species, as is also the allied *Perissectis australasiae* Don. *Oncopera intricata* Walk. does much damage to crops in Victoria. *Hectomanes* (*Fraus*) contains several rather small species with narrow wings; *H. crocea* Lucas is common at light in Eastern Australia, while *H. fusca* Meyr. often flies amongst tussocky grass in the daytime. *Pielus* and *Trictena* are Australian genera with large, mostly dull-coloured species, whose larvae tunnel in the main roots of large trees. *Trictena labyrinthica* Don. is remarkable in having antennae with three rows of pectinations. The genus *Charagia* is the endemic form of the world-wide genus *Hepialus*, from which it differs in having a wood-boring larva, broad wings and very vivid colouring. The males are usually bright green or blue with silver markings; the larger females mostly have green and red forewings and red or pink hindwings. Of the smaller species *Ch. splendens* Sc. (pl. 27, fig. 1) and the allied *Ch. lignivora* Lew. have the males green and silver; the larva of the former feeds in twigs of Lillipilli (*Eugenia*), that of the latter in Eucalypts, Wattles and other small trees; it sometimes damages fruit-trees in Victoria. *Ch. lewini* Walk. and *Ch. astathes* Turn. (pl. 27, fig. 2) feed in She-oak (*Casuarina*); the latter is confined to Western Australia, and the male has the forewing either pink, yellow, or green, with silver markings. *Ch. eximia* Sc. has a beautiful, pale blue and silver male, expanding up to 3 inches, and a much larger, green and red female. *Ch. scotti* Sc. (=*daphnandae* Lucas) has rich, velvety green forewings and pink hindwings in both sexes. *Ch. cyanochlora* Low. from N. Queensland has two types of female, one green and the other brown. *Ch. ramsayi* Sc. is a rare species found in S. Queensland and New South Wales; the male is pale green or blue and silver, the female, expanding 4½ inches, is green and silver, with pink hindwings. The largest species of all are the magnificent *Ch. nobilis* Turn. found in Western Australia and *Ch. mirabilis* Roth. from N. Queensland; the male of the latter has the forewing a delicate, evanescent blue washed with silver, the hindwing white; in the female, expanding up to 7 inches, the forewing is a beautifully mottled yellowish olive. The only New Zealand species is the fine *Ch. virescens* Dbd. (fig. Z1) confined to the North Island, where its larva bores into wineberry (*Aristotelia*), manuka (*Leptospermum*) and other trees. The genus *Leto*, having one Australian and one South African species, is a specialized offshoot from *Hepialus*. The gigantic *Leto stacyi* Sc. (pl. 29), known as the Bent-wing Moth, occurs in restricted areas around Newcastle, Gosford and Taree, New South Wales; its enormous larva (fig. Z9), up to six inches in length, makes characteristic bores in the trunks of eucalypts, and often destroys the value of the timber for use as props in coal mines. The male is orange-brown with silvery markings and a raised eye-spot on forewing; the duller female expands up to nine inches or more. This wonderful moth, when at rest, closely resembles a large lizard's head; it flies at night in the forest clearings and is attracted by light. The tunnels or

Plate 29



W. C. Davies photo.

Leto stacyi Sc. (Fam. HEPIALIDAE), male. (Natural size.)

bores of *Charagia* and *Leto* are very typical. While the larva is feeding, the entrance is covered with a silken web interwoven neatly with finely chewed bark Before pupating, the larva spins a stout, circular wad which closes the entrance like a well-fitting cork. At metamorphosis, the pupa moves up the burrow, pushes the wad out, and projects itself three-fourths of its length out of the opening before the moth emerges.

Family 4. **Anomosetidae** [Aus. 1, N.Z. 0]. Antennae very short, with whorls of bristles not differentiated ventrally; tibial spurs present; forewings with *hm*, Sc_1 and Sc_2 all present, M_4 scarcely angled with Cu_{1a}, Cu_2 complete, and only one anal vein; hindwing similar; but *hm* absent, *Sc* simple and C_2 absent. The family is represented by a unique specimen, *Anomoses hylecoetes* Turn., expanse 18 mm., taken by Dr. A. J. Turner on Mount Tambourine (2,000 ft.), S. Queensland, and superficially resembling a small, dull-coloured Hepialid. It is closely related to the South African Prototheoridae.

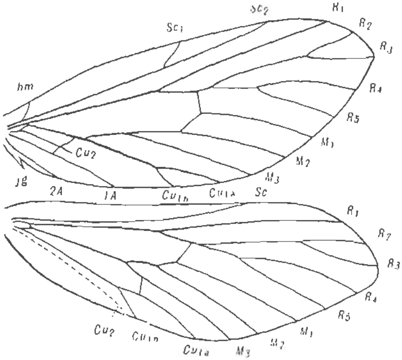


FIG. Z21. Wing-venation of *Palaeoses scholastica* Turn. Lettering as in fig. A8, p. 22; except *jg*, jugum.
[A. *Philpott* del.

Family 5. **Palaeosetidae** [Aus. 1, N.Z. 0]. Antennae as in previous family; tibial spurs absent; wings short and broad, with venation much as in previous family, but *M* arises from Cu_1, M_4 is absent, Cu_2 vestigial or absent; hindwing with *Sc* simple or forked apically. The family is represented only by a single species, *Palaeoses scholastica* Turn. (fig. Z21), discovered by Dr. A. J. Turner while sweeping foliage on the Macpherson Range (3-4,000 ft.), S. Queensland. This species is blackish in colour, expanding only 14-18 mm. It appears to be an offshoot of the previous family by reduction and specialization.

Suborder HETERONEURA

This Suborder includes more than 99 per cent. of the whole Order, comprising a great mass of forms in which the venation of the hindwing has become specialized by more or less complete fusion of *Sc* and R_1 and by reduction of *Rs* to a simple vein. In many cases, the free piece of R_1 appears as a short, oblique or transverse vein not far from the base (figs. Z39, Z46). In the pupal wing the separate tracheae *Sc* and R_1 are always present, though never equally strongly developed; the vein formed along them in the imago is designated $Sc+R_1$. Though trachea *Rs* is simple in the pupal hindwing, it should be noted that, in the imago, M_1 in most cases becomes secondarily attached to *Rs* (fig. Z30), via the cross-vein *r-m*, so that, at first sight, *Rs* appears two-branched.

An important character in the forewing in this Suborder is that the stalking of R_{2+3} is shorter than that of R_{4+5}; in the Trichoptera and Hepialoidea, the

contrary is the case. The wing-coupling is always either of the *frenate type* (p. 402 and fig. Z6, B, C) or amplexiform (fig. Z5, B).

Two main divisions can be easily recognized in practice, viz. Heterocera (all the moths except the Homoneura) and the Rhopalocera (butterflies). Recent researches tend to show that this division is a strictly scientific one, but it is a most difficult matter to frame mutually exclusive definitions of the two groups. For practical purposes, the following Key will suffice:—

> Day-flying insects with the antennae more or less swollen or clubbed distally; wing-coupling amplexiform (except in male of *Euschemon*); hindwing with *hm* present (except in Lycaenidae and some Pieridae), often enlarged. Division *RHOPALOCERA*
>
> Insects not having the above combination of characters; mostly not day-*flying, and antennae not clubbed; but, if so, then frenulum present and hm* absent in hindwing. Division *HETEROCERA*

In using this Key, the student should first examine the antennae. If these are not clubbed or more or less swollen distally, the insect belongs to the Heterocera. If the antennae are clubbed or swollen, then examine the hindwing for the frenulum; if this is present, then the insect is either one of the Heterocera (Castniidae, Aegeriidae, a few Zygaenidae and others) or else the male of *Euschemon* (pl. 40, fig. 1); *if absent, it is one of the* Rhopalocera.

Division *HETEROCERA*

This division includes eleven superfamilies, which can be separated by the following Key*:—

1. *In both wings, M and its two main branches are* complete *and strongly* formed within the cell; forewing with an areole; haustellum absent. III. COSSOIDEA
   Not as above; if *M* and its two primary branches are strongly developed, then areole absent. 2
2. *M present as a simple vein within cell, or, more rarely, branched in one* or both wings. 3
   M and its branches vestigial or absent within the basal cell. 4
3. Forewing with M_{3+4} well developed within the cell, M_{1+2} usually absent; hindwing with M_{3+4} only present, far removed from *Rs* and close to Cu_1; hindwings with Cu_2 vestigial.** IV. CASTNIOIDEA
   Forewing with main stem of *M* running right through cell of both wings as a simple vein, only branching at or near level of discocellulars; hindwings with Cu_2 completely developed. VIII. PSYCHOIDEA
4. Wings narrow or lanceolate, venation degraded. V. TINEOIDEA (part)
   Wings neither very narrow nor lanceolate,† venation not degraded. 5
5. Hindwings with Cu_2 present. 6
   Hindwings with Cu_2 vestigial or absent.‡ 8
6. Hindwings with *Rs* not approximated to $Sc+R_1$ beyond cell. 7
   Hindwings with *Rs* approximated to, or partially fusing with, $Sc+R_1$ beyond cell. VII. PYRALOIDEA (part)
7. Wings not cleft; legs of moderate length. V. TINEOIDEA (part)
   Wings usually cleft; legs very long and slender, with long tibial spurs. VI. PTEROPHOROIDEA
8. Forewings with M_2 approximated at origin to Cu_{1a}. 9
   Forewings with M_2 not approximated at origin to Cu_{1a}.§ 12
9. Frenulum absent; hindwings with a closed subcostal cell formed basally between *Sc* and *R*, and having one or more veinlets arising from it. IX. LASIOCAMPOIDEA
   Frenulum nearly always present; hindwings without subcostal cell. 10
10. Hindwings with *Rs* approximated to $Sc+R_1$ beyond cell. 11
    Hindwings with *Rs* well separated from $Sc+R_1$. X. NOCTUOIDEA

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*The Keys to the Superfamilies and Families of this great Division are the work of Dr. A. Jefferis Turner, who has also provided the definitions of the imaginal *characters for the separate families.*

**In South American genera the areole and Cu_2 of hindwing are fully developed.

†Except *Oxychirota* (Pyraloidea).

‡Except *Gastridiota* (Bombycoidea).

§Except *Antimimistis* and *Microdes* (Notodontoidea, Larentiidae).

11. Hindwings with *3A* well developed and reaching tornus.* VII. PYRALOIDEA. (part)
Hindwings with *3A* absent or not reaching tornus. X. NOCTUOIDEA. (Drepanidae only)

12. Forewings without areole, R_5 well separated from R_4 and usually stalked with M_1. XI. URANIOIDEA
Forewings with R_5 arising from areole, or stalked with R_4. 13

13. Forewings with cell of moderate size, areole often present. XII. NOTODONTOIDEA
Forewings with cell small, areole absent. XIII. BOMBYCOIDEA

Superfamily III. COSSOIDEA

Family 6. **Cossidae** (Wood Moths) [Aus. 36, N.Z. 0]. Maxillary palpi and haustellum absent; labial palpi short or minute. Tibial spurs variable. *M* and its two primary branches strongly developed within the cell in both wings (the branches coalesced in both wings of the European genus *Stygia* and hindwing of *Dyspessa*). Forewings with areole present, often large and extended towards base so that R_1 arises from it; Cu_2 developed, *2A* looped with *1A*. Hindwings with free piece of R_1 present or absent, Cu_2 complete or nearly so, *1A* forming a small basal Y-vein with *2A*; *3A* present (fig. Z22). Frenulum present. Larvae wood-borers. Pupa with abdominal spiracles 1-2 hidden. Absent from New Zealand.

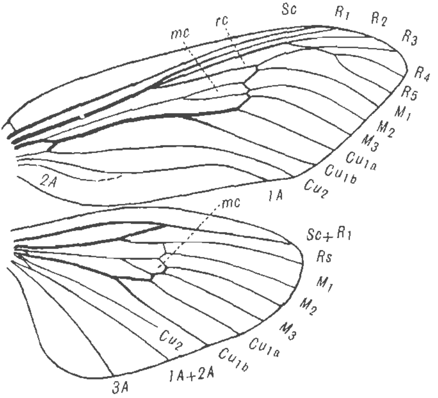


FIG. Z22. Wing-venation of *Xyleutes eucalypti* Sc., Australia. Fam. Cossidae. Lettering as in fig. A8, p. 22; except *mc*, median cell; *rc*, areole. [*R. J. T. del.*

This family of medium to very large species, mostly without any regular colour pattern, is well represented in Australia. The Cossinae have pupae with seg. 3 of abdomen fixed; they include three primitive, endemic genera, *Culama*, *Cossodes* (Western Australia only) and *Ptilomacra*. *Culama australis* Walk. is a common, mottled grey moth expanding up to three inches; the pinkish larvae bore gregariously in the branches and trunks of various trees. *Ptilomacra senex* Walk. is a handsome, very woolly, dark grey moth with strongly pectinate antennae; it comes readily to light, and plasters its hard, oval eggs in a cylindrical mass round small twigs and grass-stems, like those of the Planipennian family Ascalaphidae. *Dudgeona*, found also in India, contains species with the reddish-brown forewings

*Both anal veins absent in the Oxychirotidae.

marked with silver. The Zeuzerinae, in which the pupa has seg. 3 movable, include two Queensland species of the Leopard moths, genus *Zeuzera*, and a large number of mottled grey or brownish species of the dominant genus *Xyleutes*. Amongst the latter are some enormous species whose larvae feed in the wood of eucalypts; *X. boisduvali* H.-Sch. expands up to 10 inches, with an abdomen as big as a small banana; the female lays thousands of small spherical eggs. Larvae of this species measure up to 7 inches in length, and pupae up to 5 inches. *X. donovani* Roth. (pl. 35, fig. 1) is a much smaller and rarer species from Queensland. The larvae of this genus burrow vertically in the heart-wood of the tree; when full-fed, they bore a horizontal gallery opening on to the exterior by a large round hole, which is carefully closed up with a wad of chewed wood; they then retreat to the old vertical burrow, close it up with a viscous secretion and a felted pad, and finally pupate head downwards.

Superfamily IV. CASTNIOIDEA

Family 7. **Castniidae** [Aus. 25, N.Z. 0]. Maxillary palpi present; haustellum present or absent; labial palpi short or moderate. Antennae smooth, clubbed apically. Tibial spurs present. *M* and its second primary branch strongly deve-

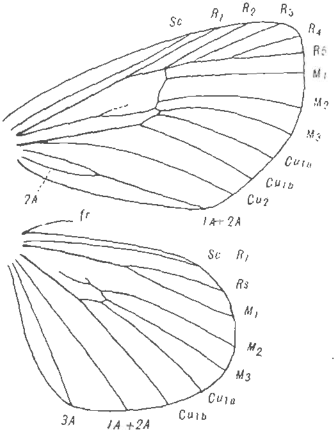


FIG. Z23. Wing-venation of *Synemon leucospila* Meyr., Australia. Fam. Castniidae. Lettering as in fig. A8, p. 22; except *fr*, frenulum. [*A. Philpott del.*

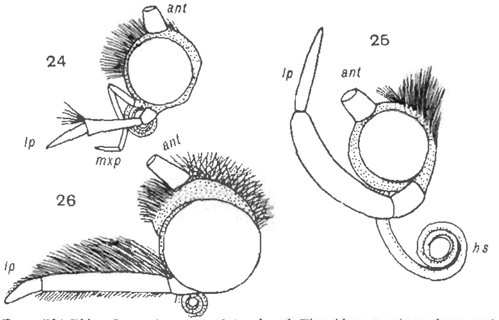
loped within the cell, but M_{1+2} vestigial or absent (rarely present in forewing in some species of *Synemon*); Cu_2 variable. Forewing with or without areole; *2A* usually making a long loop with *1A*. Hindwing with *1A* forming a small basal Y-vein with *2A*, *3A* present (fig. Z23). Frenulum present. Day-flying species; the larvae burrowing in stems or amongst the roots of grasses. Absent from New Zealand.

This small, archaic family is represented by one Oriental and a few Neotropical genera, and by the endemic genus *Synemon* in Australia. This genus has Cu_2 absent (or only distally developed in forewing) and there is no areole. The forewings are protectively coloured in mottled grey, fuscous or brownish; the hindwings are fuscous, yellow, orange, or crimson. Western Australia is their headquarters. They fly by day in open spaces, resting on the ground and displaying their hindwings. Little is known of their life history. *S. hesperoides* Feld.

(pl. 30, fig. 4) is not uncommon at times in Eastern Australia; the hindwing is fuscous in the male, pale yellowish in the female. Of the Western Australian species, the finest are *S. directa* Walk., expanding 2 inches, with forewings strongly banded with white, and with black and orange hindwings, and *S. catocaloides* Walk., slightly smaller, with crimson and black hindwings.

Superfamily V. TINEOIDEA

This is an immense group, equalling or perhaps surpassing in number of species all the rest of the Order taken together. Only a few are of moderate size, these being internal feeders; most of the species are small, and there are a number of highly reduced groups with leaf-mining larvae and narrow hindwings with reduced venation and long fringes, such as occur in the Trichopterous family *Hydroptilidae*. Maxillary palpi frequently present, (well developed and 5-segmented in some Tineidae); haustellum and labial palpi usually present. Venation of the Cossoid type, but with *M* usually absent, never strongly developed within the cell. The chorda (R_{4+5}) is represented in the pupa by a strong trachea, but nearly always fails to become chitinized at metamorphosis (figs. Z27, Z30); thus the basal cell of the forewing becomes a true areocel. Larval habits very variable, but all forms adopt some mode of concealment (tunnelling, mining, spinning leaves together, or constructing portable cases).



FIGS. Z24-Z26. Lateral views of heads of Tineoidea, to show form and position of labial palpi (*lp*); *ant*, scape of antennae; *hs*, haustellum *lp*, labial palp; *mxp*, maxillary palp.
FIG. Z24. *Tinea mysticopa* Meyr., New Zealand. Fam. Tineidae, subfam Tineinae. Palpi porrected. [*R. J. T. del.*
FIG. Z25. *Proteodes carnifex* Butl., New Zealand. Fam. Oecophoridae, subfam. Oecophorinae. Palpi long, sickle-shaped and ascending. [*R. J. T. del*
FIG. Z26. *Tortrix excessana* Walk., New Zealand. Fam. Tortricidae. Palpi with distal segment short, cylindrical, obtuse. [*R. J. T. del*

The group as here defined includes the superfamily Tortricoidea: the only distinguishing character, viz., the shape of the labial palpi, cannot be considered as of superfamily value. This section, however, forms a natural group, probably descended from a common stem with the Glyphipterygidae, and may be distinguished by the sectional name Tortricites.

The Classification of the group is very difficult. The following Key will probably prove reliable in the great majority of instances, but the exceptions given in the footnotes are almost certainly far from complete.—

1.	Maxillary palpi long, folded, 5-segmented.	Fam. 8. TINEIDAE (part)
	Maxillary palpi short and not folded, or absent.	2
2.	Head shortly rough-haired.	Fam. 8. TINEIDAE (part)
	Head smooth or tufted, not shortly rough-haired.	3
3.	Maxillary palpi filiform, 3-segmented, rarely minute.	4
	Maxillary palpi vestigial or absent.	5

4 Hindwings ovate or lanceolate; tibiae smooth. Fam. 9. PLUTELLIDAE
Hindwings linear-lanceolate; tibiae usually covered with short bristles or partly thickened with scales. Fam. 10. GRACILARIIDAE
5. Tibial spurs absent. Fam. 11. EPIPYROPIDAE
Tibial spurs present. 6
6. Hindwings with *3A* distally forked. Fam. 12. CYCLOTORNIDAE
Hindwings with *3A* simple. 7
7. Hindwings with *Sc* concealed in a costal fold. Fam. 18. AEGERIIDAE
Hindwings with *Sc* not concealed. 8
8 Hind tarsi with whorls of bristles at apices of segments. Fam. 16. HELIODINIDAE
Hind tarsi without whorls of bristles. 9
9 Hindwings linear-lanceolate, narrower than forewings. Fam. 22. ELACHISTIDAE
Hindwings not linear-lanceolate.* 10
10. Labial palpi with distal segment long, more or less pointed, or short and acute.† 11
Labial palpi with distal segment short, cylindrical, obtuse, (Section TORTRICITES). 17
11. Hindwings with a cubital pecten (see p. 400). Fam. 17. COPROMORPHIDAE
Hindwings without a cubital pecten. 12
12. Labial palpi short or moderate, porrect, or, if ascending, then not exceeding vertex; distal segment short or moderate. 13
Labial palpi long or very long, ascending, much exceeding vertex,‡ usually sickle-shaped; distal segment moderate or long, very acute.§ 15
13. Labial palpi short, porrect; hindwings broader than forewings, termen sinuate. Fam. 13. AMPHITHERIDAE
Labial palpi not short and porrect, or, if so, hindwings not broader than forewings, termen not sinuate. 14
14 Labial palpi with second segment smooth and slender. Fam. 14. HYPONOMEUTIDAE
Labial palpi with second segment thickened or hairy.** Fam. 15. GLYPHIPTERYGIDAE
15. Hindwings with $Sc+R_1$ connected with, or approximated to, basal part of cell; *Rs* and M_1 stalked or approximated at origin. 16
Hindwings with $Sc+R_1$ well separated from basal part of cell; *Rs* and M_1 separate, parallel.†† Fam. 19. OECOPHORIDAE
16. Forewings with Cu_{1b} from long before angle of cell. Fam. 20. XYLORYCTIDAE
Forewings from Cu_{1b} from near angle of cell. Fam. 21. GELECHIIDAE
17. Forewings with Cu_{1b} from near angle of cell 18
Forewings from Cu_{1b} from before three-fourths of cell. 19
18 Hindwings with M_2 absent. Fam. 27. CARPOSINIDAE
Hindwings with M_2 present. Fam. 26. PHALONIIDAE
19. Hindwings with cubital pecten on margin of cell Fam. 24. EUCOSMIDAE
Hindwings without cubital pecten. 20
20. Forewings with R_3 and R_4 stalked or coincident; hindwings with M_2 parallel to M_3. Fam. 23. CHLIDANOTIDAE
Forewings with R_3 and R_4 not stalked, or, if so, then hindwings with M_2 approximated at base to M_3. Fam. 25. TORTRICIDAE

Family 8. **Tineidae** [Aus. 394, N.Z. 97]. Head shortly rough-haired (sometimes smooth in Lyonetiinae); maxillary palpi (fig. Z24) either slender, folded, 5-segmented, or entirely absent, or more rarely present but short; labial palpi (fig. Z24) short or moderate, porrected or subascending, more or less obtuse (vestigial or absent in *Bucculatrix* and *Leucoptera*). A large family,

*Except *Zelleria* and one or two allied genera in the Hyponomeutidae.
†Apex obtuse in *Simaethis* of the Glyphipterygidae.
‡Short in *Eupselia* and *Aeolocosma* of the Oecophoridae.
§Distal segment aborted in males of *Anarsia* of the Gelechiidae
**Slender in *Plestoceros*: scarcely thickened in *Tortyra*.
††Except in *Heteriptolis*.

divisible into five well-marked subfamilies, considered by some authors as of full family rank.

The Adelinae have the antennae of the males 2-4 times as long as forewings, those of females rather shorter; eyes of males often much enlarged; the larvae

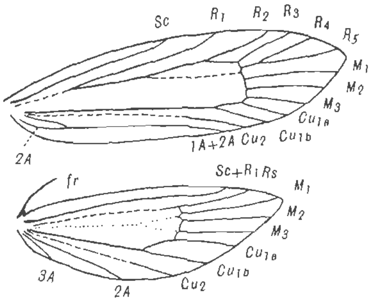


FIG. Z27. Wing-venation of *Tinea terranea* Butl., New Zealand. Fam. Tineidae, subfam. Tineinae. Lettering as in fig. A8, p. 22, except *fr*, frenulum. [*A. Philpott del.*

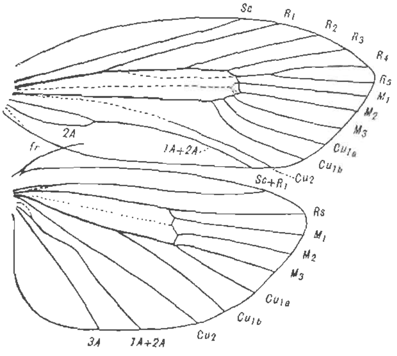


FIG. Z28. Wing-venation of *Wingia lambertella* Wing. Australia. Fam. Oecophoridae, subfam. Philobotinae. Lettering as in fig. A8, p. 22, except *fr*, frenulum. The dotted lines indicate the courses of veins that fail to chitinize; note especially the short basal piece of *1A* in hindwing, looped with *2A*. [*R. J. T. del.*

make broad, flat cases of fallen leaves. Most of the Australian species belong to the day-flying genus *Nemotois*, with brilliantly metallic, gold and purple wings. *N. sparsella* Walk. (pl. 27, fig. 3) is the commonest species. Absent from New Zealand.

The Tineinae are a very large group with rough head and primitive venation; antennae seldom as long as forewings; larvae of variable habits, often living in a portable case, feeding on leaves, lichens, dried vegetable refuse, etc. One of the most primitive genus is the New Zealand *Titanomis* with two very rare species of

rather large size, closely resembling small Cossidae, but with the haustellum and palpi present. *T. sisyrota* Meyr. is dark grey, expanding 40 mm. The Australian genus *Moerarchis* contains two large and handsome species, expanding up to 30 mm., with orange hairs on head, and forewings chocolate, strongly marked with creamy blotches and fasciae; *M. australasiella* Don. (pl. 27, fig. 4) is fairly common in Eastern Australia, *M. dictyotis* Meyr. in W.A. *Narycia* is a large Australian genus whose larvae are case-bearers and feed on lichens; *N. palleuca* Meyr. (pl. 33, fig. 1) is a whitish species, tinged with buff; *N. trifasciana* Walk. (pl. 28, fig. 6) is brown with creamy fasciae; *N. saxosa* Meyr. is twice as large, speckled brown and pale grey; *Iphierga euphragma* Meyr. (pl. 28, fig. 7) has forewing banded with black and white. The cosmopolitan genus *Tinea* is well represented in both countries. The Australian *T. xystidophora* Meyr. (pl. 28, fig. 8) is a beautiful species with lemon yellow forewings having the apical third mottled brown and grey; *T. purella* Walk. has rich buff forewings with dark apical third. In New Zealand, there is a peculiar group of species of this genus, of which *T. margaritis* Meyr. is a good example, whose colouring mimics that of species of *Glyphipteryx*. *T. dicharacta* Meyr. is common to both countries. Other prettily marked Australian species belong to *Monopis*, *Ardiosteres* and *Lepidoscia*. *Mallobathra* is well represented in New Zealand. The European genus *Taleporia* (pl. 28, fig. 9) is represented by endemic species in both countries. The New Zealand species *Sagephora phortigella* Meyr. (pl. 28, fig. 10) has dull whitish forewings with elongate blackish mark on costa. The three introduced clothes-moths, *Tinea fuscipunctella* Haw., *Tineola bisselliella* Haw. and *Trichophaga tapetiella* L. occur commonly in both countries and do considerable damage.

The Lyonetiinae have the crown of the head usually rough-scaled, sometimes smooth; the antennae have the scape often hollowed beneath and dilated anteriorly with scales so as to form an eye-cap; forewings with apex bent upwards or downwards. The species are all small or minute, mostly leaf-miners. *Bucculatrix* and *Leucoptera* are peculiar in having both pairs of palpi vestigial. *Opogona* is well represented in Australia by some handsome species with yellow forewings marked with brown or purple; *O. comptella* Walk. (pl. 27, fig. 6) is a common species, also introduced into New Zealand. *Comodica tigrina* Turn. (pl. 27, fig. 5) and *C. mystacinella* Walk. are also handsome species. *Lyonetia*, *Leucoptera*, *Phyllocnistis* and allies contain mostly very small, whitish species, 3-5 mm. in expanse. *Erechthias* and allies are a group of genera largely developed in Australia and also found in New Zealand. The cosmopolitan *Bedellia somnulentella* Zell. occurs in both countries.

The Oposteginae contain only the single widespread genus *Opostega*, common in Australia, which has long, folded maxillary palpi, short labial palpi, scape of antenna hollowed out to form an eye-cap, and hind tibiae with much elongated inner median spur; the venation is extremely degraded. *O. gephyraea* Meyr. is the best known species.

The Nepticulinae contain only the cosmopolitan genus *Nepticula*, which includes the tiniest of all Lepidoptera, only 3-4 mm. in expanse. They resemble the Lyonetiinae, but have the venation greatly reduced. A small jugal lobe is present on the forewings of some members of this genus. The larvae are leaf-miners; M. Watt has given a good account of the native New Zealand species.

Family 9. **Plutellidae** [Aus. 25, N.Z. 24]. Head smooth; maxillary palpi short, 3-segmented, filiform, porrect; labial palpi moderately long, ascending, distal segment long, slender, acute. Hindwings elongate-ovate. Larvae leaf-feeders. A small family. *Orthenches* occurs in both countries, but is most abundantly developed in New Zealand; *O. glyptarcha* Meyr. (pl. 28, fig. 11) is a handsome species with dark, burnished forewings marked with whitish. *Protosynaema eratopis* Meyr. has broader wings, similarly but more broadly marked. Of the Australian species, *Tonza purella* Walk. is the finest; it expands 12 mm., and the slender, silvery forewings are excavated at the apex. Other genera are *Niphonympha*, *Paraphyllis* and *Phalangitis*. Of the cosmopolitan genus *Plutella* there are two native New Zealand species; two introduced species occur in both countries, one being the exceedingly common and injurious cabbage-moth, or diamond-back moth, *P. maculipennis* Curt. (=*P. cruciferarum* Zell.).

Family 10. **Gracilariidae** [Aus. 138, N.Z. 18]. Head smooth; antennae as long as, or longer than forewings; palpi as in Plutellidae; middle tibiae often thickened, with scales at apex; hind tibiae smooth or with short bristles. Forewings narrow, hindwings linear-lanceolate. Larvae leaf-miners, pupating outside the mine. A rather large family. The widespread genera *Gracilaria* and *Parectopa* are well represented in both countries. *G. xanthopharella* Meyr. and *P. ida* Meyr.

(pl. 28, fig. 12) are beautiful Australian species, the former with pale yellow and reddish purple forewings, the latter with rosy forewings with oblique silvery markings. *G. chrysitis* Feld. (pl. 28, fig. 14), *G. selenitis* Meyr., *P. citharoda* Meyr. and *P. sorionella* Huds. (pl. 28, fig. 13) are pretty New Zealand species. *Acrocercops* is a world-wide genus, very largely represented in Australia; it contains minute species, 4-5 mm. in expanse, some brilliantly metallic in colouring, like *A. cunctalla* Meyr., others with white and brown forewings, like *A. macaria* Turn. *Epicephala* is an allied genus found in Australia, India and Africa, with loose hairs on the head. The larva feeds inside seeds; the moth emerges and remains inside until the dried seed-capsule splits open and liberates it. Most of the species of this family are easily recognised by their peculiar habit of resting with the fore part of the body raised up at a steep angle.

Family 11. **Epipyropidae** [Aus. 8, N.Z. 0]. Head shortly hairy; antennae short, pectinate to apex in both sexes; both pairs of palpi vestigial or absent; tibiae without spurs. Forewings with R_1 absent, areole present, chorda and media weakly developed inside basal cell, Cu_2 developed distally only; hindwings with $Sc+R_1$ well separated from the narrow basal cell, Cu_2 present. A small family represented only by the genus *Epipyrops* in Australia; absent from New Zealand. The larvae are parasitic upon leaf- and plant-hoppers (Jassidae and Fulgoroidea); the moths are small and dark in colour. Perkins (1905) has given a good account of the Queensland species.

Family 12. **Cyclotornidae** [Aus. 5, N.Z. 0]. Head with appressed scales; maxillary palpi absent, labial palpi minute; tibial spurs well developed. Wings with all veins present and separate, media with its two primary branches developed within cell; forewing with chorda present, Cu_2 developed towards apex only; hindwing with *3A* distally forked. A small family represented only by the genus *Cyclotorna* in Queensland; absent from New Zealand. The larvae pass the first instar as parasites in various Homoptera; they then spin cocoons from which they emerge as second instar larvae, which live in ants' nests (F. P. Dodd, 1911). *Cyclotorna monocentra* Meyr. (pl. 32, fig. 1) expands 20 mm., forewings grey-brown with a dark brown mark. *C. egena* Meyr. is a much smaller, dull brownish species.

Family 13. **Amphitheridae** [Aus. 4, N.Z. 0]. Head rough-haired on crown; antennae longer than forewing, scape with a pecten; maxillary palpi absent, labial palpi moderate, slender, porrect. Eyes of male incised posteriorly or completely divided by a horizontal ridge of scales. Hindwings considerably broader than forewings, with sinuate termen and veins *Rs*, M_1 and M_2 parallel. A small family of only seven species, four of which are found in Australia and three in India. *Amphithera heteroleuca* Turn. (pl. 28, figs. 15, 16) is dark brown with a whitish blotch near apex of forewing and a white tip to the abdomen, the male has the eyes divided into two.

Family 14. **Hyponomeutidae** [Aus. 100, N.Z. 3]. Head with appressed scales or with anterior tuft of hair; maxillary palpi vestigial or absent; labial palpi moderate, ascending or porrect, slender, nearly always smooth-scaled; hind tibiae usually smooth. Hindwings usually elongate-ovate with short fringe, but sometimes lanceolate with longer fringe. A family of moderate size; many of the species are very beautiful, expanding 12-25 mm. *Hyponomeuta* contains species with white or grey wings, the forewings spotted with black, such as *H. myriosemus* Turn. (pl. 33, fig. 2); the larvae live gregariously in a small web on leaves or twigs. The species of *Ethmia* are similarly marked, but the hindwings are sometimes orange. *Atteva niphocosma* Turn. (pl. 27, fig. 9) and two allied species have lovely orange or fulvous wings, the forewings densely marked with white spots. *Lactura* is a fairly large genus containing beautifully coloured species; *L. erythractis* Meyr. (pl. 27, fig. 8) and allied species are yellow or orange, the forewings intricately marked with red; *L. suffusa* Walk. is a fine Queensland species expanding up to 30 mm., varying from orange to nearly black in colour; *L. caminaea* Meyr., (pl. 27, fig. 7) has rose-brown forewings with three small white spots, hindwings orange and rose-brown. The genera *Zelleria*, *Prays* and *Xyrosaris* form a group of small species, 6-12 mm. in expanse, with much narrower wings; the three New Zealand species all belong to *Zelleria*.

Family 15. **Glyphipterygidae** [Aus. 116, N.Z. 53]. Head with appressed scales; maxillary palpi vestigial or absent; labial palpi moderate, ascending, seg. 2 nearly always thickened or hairy, seg. 3 often laterally compressed, usually acute; hind tibiae usually smooth. Hindwings without cubital pecten, fringe often short. A fairly large family containing species mostly of small size. *Glyphipteryx* is a

large genus with numerous species in New Zealand and Eastern Australia; the dark forewings usually have brassy or metallic markings, as in *G. zelota*, Meyr. (pl. 28, fig. 17); their larvae feed on rushes and sedges. The Australian *Choreutis lampadias* Meyr. (pl. 28, fig. 18) has brown forewings with metallic blotches and two whitish fasciae. *Simaethis* is a tropical genus with curious, blunt palpi; it extends into both countries; the broad wings are held triangularly when at rest. *S. basalis* Feld. (pl. 27, fig. 10) and *S. sycopola* Meyr. are well-known Australian species whose larvae feed on native fig-trees (*Ficus*). *Cebysa leucoteles* Walk. (pl. 27, fig. 11) is a unique form, in which the male has well developed wings, the forewings brown, the hindwings orange with black border, but the female has only partially developed wings with metallic blue-green scales and apical border orange; it occurs in S.E. Australia. The larva lives in a silken bag covered with scraps of bark or lichen; the adult males swarm to the female. *Heliostibes* is found in New Zealand and South America; *H. electrica* Meyr. (pl. 28, fig. 19) is one of the finest species. *Imma* and *Sagalassa* are well represented in Australia; *I. eleis* Feld. found in N. Queensland and Papua, expands 20 mm. and is blackish with a broad orange band across all four wings.

Family 16. **Heliodinidae** [Aus. 94, N.Z. 17]. Head smooth; antennae often long; maxillary palpi vestigial or absent; labial palpi usually long, recurved; hind tarsi and usually also tibiae with whorls of bristles at end of each segment and at origins of spurs. Forewings narrow or very narrow; hindwings from narrowly elongate-ovate to lanceolate or linear. A fairly large family, derived from the previous one, the species being reduced in size and with much narrower wings. The hind legs are displayed in repose and are of very distinctive structure. The principal genus is *Stathmopoda*, in which the larvae of most species feed on Coccidae and are beneficial. *S. crocophanes* Meyr. and *S. callichrysa* Low. (pl. 28, fig. 20) are commonly bred from mealy-bugs on wattles (*Acacia*). The larva of *S. phlegyra* Meyr. bores into the fruit of the New Zealand Lacebark (*Hoheria populnea*). The larvae of *S. arachnophthora* Turn. feeds on spider's eggs in Queensland. *Eretmocera* contains three lovely Australian species found resting on flowers of Compositae. *Thylacosceles* has two species in New Zealand and two in Ceylon. The remarkable Australian genera *Pseudaegeria* and *Snellenia*

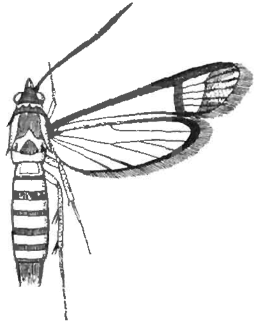


FIG. Z29. *Trochilium chrysophanes* Meyr., female, Australia. Fam. Aegeriidae (x 4).

mimic the red Soldier Beetles of the genus *Metriorrhynchus*; *S. lineata* Walk., expanding 10-12 mm., is found occasionally in Eastern Australia; *P. polytita* Turn. is larger, with broader red wings.

Family 17. **Copromorphidae** [Aus. 7, N.Z. 3]. Maxillary palpi absent; labial palpi usually recurved, ascending, not exceeding vertex, rarely long and porrect. Forewings with R_4 and R_5 stalked or separate; hindwings broader, with a pecten of hairs on Cu_1; Rs and M_1 separate and parallel, fringes short. A small family confined to Australia and New Zealand. *Hypertropha tortriciformis* Gn.

(pl. 27, fig. 12) is common in Eastern Australia and Tasmania. Other genera are *Copromorpha* and *Osidryas* in Australia, *Isonomeutis* and *Phycomorpha* in New Zealand.

Family 18. **Aegeriidae** (Clearwing Moths) [Aus. 15, N.Z. 0]. Antennae often dilated towards apex; maxillary palpi vestigial or absent; labial palpi moderate, curved, ascending, acute. Hindwings with $Sc+R_1$ concealed in a costal fold. Either hindwing only, or both wings, largely hyaline and scaleless. The genus *Melittia*, with clubbed antennae and tufts on hind legs, occurs in N. Queensland; *M. amboinensis* Feld. is found buzzing around flowers. *Diapyra igniflua* Lucas, 10-15 mm. in expanse, with red and black forewings, has been bred from the quandong (*Santalum acuminatum*). *Paranthrene oberthuri* Le Cerf expands an inch; the forewing is orange with a black border. *Trochilium chrysophanes* Meyr. (fig. Z29) is a handsome species of a very widespread genus. The introduced currant borer, *Trochilium tipuliforme* L., does damage in Tasmania and New Zealand.

Family 19. **Oecophoridae** [Aus. 1515, N.Z. 149]. Head with appressed or loose scales, side tufts often spreading, antennae usually with basal pecten (sometimes weak or absent); maxillary palpi vestigial or absent; labial palpi (fig. Z25) curved, ascending, nearly always long and sickle-shaped; hind tibiae rough-haired. Forewing with R_4 and R_5 stalked or rarely coincident; hindwing not broader than forewing, ovate, more rarely lanceolate, with all veins present, $Sc+R_1$ well separated from cell throughout, Rs and M_1 separate, parallel. Larvae of variable habits, spinning leaves together or constructing various forms of cases. The life histories of many of the chief Australian genera are quite unknown.

This is a large and widespread family, but only in Australia and New Zealand does it outnumber the Gelechiidae. Australia possesses more than half the total known species for the world. Five subfamilies are recognised, but they are only distinguished by very slight characters.

The Depressariinae have the antennae in the male simple or nearly so; the pupae are often not enclosed in a cocoon, but are placed erect, attached to a silken bag by the cremaster. This group is only moderately represented in both countries. The cosmopolitan genus *Cryptolechia* occurs in both countries, as does also the large Australian genus *Eutorna*. *C. radiosella* Walk. (pl. 28, fig. 21) is a fine Australian species with grey forewings marked with whitish rays. The principal Australian genera are *Eupselia*, a group of Eucalyptus-feeders with usually short palpi, and *Thudaca* (pl. 28, fig. 22), peculiar in having a vertical tuft on the head, and silver markings on the forewing. *Barantola*, *Scarpiopsis* and other small genera contain species of exceptional beauty

The Eulechriinae have the antennae in the male moderately or strongly ciliated, and R_5 running to apex of forewing. This group is very numerous in both countries. The great genus *Eulechria* (pl. 28, fig. 23) contains 244 species, all Australian except one New Zealand, one South African and four Oriental species. *Trachypepla*, with tufted forewings, contains twenty New Zealand species, and a smaller number in Australia. *Barea* has 50 species in Eastern Australia and Tasmania, one in New Zealand and one common to both countries. *Machimia* contains 50 species in Australia and a larger number in South America *M. pudica* Zell. (pl. 30, fig. 1) has pinkish forewings with a large dark spot. The smaller genera *Tisobarica*, *Callithauma* and *Aglaodes* contain some exquisitely coloured species, such as *T. pyrrhella* Turn. (pl. 28, fig. 24) with deep red and yellow forewings. The small species of *Petalanthes* have the hindwings spotted with white or pale yellow. These last four genera are peculiar to Australia. *Atomotricha* is an endemic New Zealand genus with eight species, in several of which the female is semi-apterous.

The Philobotinae differ from the Eulechriinae only in having R_5 running to the termen of forewing. They are very poorly represented in New Zealand by two endemic species of *Philobota* and one of *Oxythecta*; but in Australia they are immensely developed. The great genus *Philobota* with about 300 species is almost entirely Australian; many of the species are common, and most of them conspicuous, of fairly large size (expanding 20-25 mm.) and often brightly coloured, but in no case has the larva been discovered. *P. sophia* Turn. (pl. 28, fig. 25) and *P. arabella* Newm. (pl. 28, fig. 26) are two of the most beautiful species; the latters is very common around Sydney in the spring. *Wingia* includes several very fine species expanding 25-40 mm., found in South-Eastern Australia and Tasmania; the larvae spin bunches of Eucalyptus leaves together and pupate in their webs. *W. lambertella* Wing. (pl. 27, fig. 13) is the finest species; *W. hesperidella* Meyr. is somewhat smaller, with rich gold and orange forewings. *Tortri-*

copsis aurata Walk. (pl. 27, fig. 14) is an orange species with peculiarly shaped forewing. *Coesyra* contains a number of handsome species expanding 20-25 mm. with yellow or orange forewing marked with brown or purple; one of the best known is *C. dichroella* Zell. (pl. 27, fig. 15). The beautiful *Aristeis hepialella* Walk. (pl. 28, fig. 28) has rich yellow and fulvous forewings with a silver spot on them. *Chrysonoma argutella* Zell. (pl. 28, fig. 27) is a very handsome species with forewing strongly patterned in gold and black. *Zonopetala* (pl. 28, fig. 29) and *Eriodyta* (pl. 28, fig. 30) contain smaller species, mostly transversely banded with white and brown or black. The small species of *Lophopepla*, *Lepidotarsa* and *Eclecta*, expanding 12-15 mm., are remarkably beautiful; *Lepidotarsa chryserythra* Turn. (pl. 28, fig. 31) has rich red forewing spotted with yellow and having a waved dark dorsum; *Eclecta aurorella* Meyr. (pl. 28, fig. 32) has rosy forewings streaked with silver and black. All the above are endemic Australian genera; the allied *Pleurota* occurs in Australia and Europe.

The Oecophorinae have R_5 ending on costa of forewing. They are not so extensively developed in Australia as the two previous groups, but are very well represented in New Zealand. The widely distributed genus *Borkhausenia* has about sixty species in each country, rather small insects (expanding 10-17 mm.) with forewings ranging from grey to orange with darker markings; *B. plagiatella* Walk. (pl. 28, fig. 33) and the handsome *B. chrysogramma* Meyr. (pl. 38, fig. 2) are well-known New Zealand species. *Macrobathra* has 74 Australian 9 Indian and 4 African species; *M. argonota* Meyr. (pl. 28, fig. 35) has strongly marked, black and white forewings. *Gymnobathra* and *Thamnosara*, both closely allied to *Borkhausenia*, are peculiar to New Zealand. *G. flavidella* Walk. (pl. 28, fig. 36) has pale yellow forewings. *Izatha peroncanella* Walk. (pl. 38, fig. 3) is a handsome representative of a very distinct and isolated genus containing 16 species, confined to New Zealand. Other endemic New Zealand genera are *Compsistis* and *Aochleta*.

The Blastobasinae are a small subfamily of small and very obscurely coloured moths, represented in Australia only by a few species of *Blastobasis*.

The only species of economic importance is *Latometus pilipes*, Butl., (subfamily Philobotinae), a whitish insect with dark longitudinal stripe on forewing, which is reported as damaging wheat in South Queensland. Dr. Turner has recorded a species, *Neossiosynoeca scatophaga* Turn., from North Queensland, whose larvae inhabit the nests of a Parrot (*Psephotus chrysopterygius*), excavated out of large termitaria; they feed on the excreta of the young parrots, even cleaning their feet and feathers.

Family 20. **Xyloryctidae** [Aus. 269, N.Z. 2]. Head smooth or with loosely appressed hairs; antennae always without basal pecten; maxillary palpi vestigial or absent; labial palpi long, curved, ascending, sickle-shaped, seg. 3 slender, acute. Forewings with R_4 and R_5 usually stalked, sometimes separate or coincident, Cu_{1b} from before three-fourths of basal cell. Hindwings as broad as, or slightly broader than forewings, ovate; $Sc+R_1$ approximated or connected with basal cell towards base; Rs and M_1 approximated, connate or stalked.

This family, which contains many of the largest Tineoidea, is well represented in Australia, but there are only two New Zealand species. Few species occur elsewhere except in South America. The larvae of the larger species burrow in stems, either feeding on the bark or emerging at night to bite through the leaf-stalks, dragging the leaves to the mouths of their retreats; those of the smaller species make galleries amongst spun foliage in cones of Banksia, etc. The finest species belong to *Cryptophasa*, *Xylorycta*, *Maroga* and *Uzucha*. The depredations of the large genus *Cryptophasa* are very noticeable in the bush; *C. rubescens* Lew., expanse 35-60 mm., with brown forewings and orange hindwings, feeds on wattles (*Acacia*), the speckled grey *C. irrorata* Lew. on she-oaks (*Casuarina*), and *C. nigricincta* Turn. on eucalypts; in this species the forewing is fuscous in the small male, creamy in the large female; *C. nymphidias* Turn. (pl. 33, fig. 3) is pure white; *C. flavolineata* Walk. (pl. 33, fig. 4) white with slender, longitudinal, yellow stripes in forewing; its larvae feeds on Banksia. In the genus *Xylorycta*, the most beautiful species is *X. porphyrinella* Walk. (pl. 27, fig. 16); its larva feeds in Native Cherry (*Exocarpus*). *X. strigata* Lew. is a smaller species with whitish forewings having a longitudinal, brownish stripe; its larva burrows in the terminal twigs of Banksia. *Uzucha humeralis* Walk. (pl. 30, fig. 2), from Queensland, is a dull brownish moth expanding two inches, the forewing of the costa greatly arched basally, the hindwing shading to pale yellow in apical third; the larvae feed in covered galleries on the smooth bark of *Angophora*. *Maroga setiotricha* Meyr., expanding 2-3 inches, has grey

forewings, the veins partially outlined in dark brown, hindwings dark brown. The Cherry-tree Borer, *M. unipunctana* Walk., expanding 35-70 mm., is creamy-white with a discal black spot on the forewing; its larva originally fed on the bark of wattles, frequently ringbarking whole limbs of the tree, but now does considerable damage to fruit-trees and elms. *Eschatura lemurias* Meyr. (pl. 33, fig. 5) has the forewings pale buff or fulvous, with peculiarly shaped apex; the larva of this species also is a bark-feeder. Of smaller species we may mention *Neodrepta luteotactella* Walk. (pl. 33, fig. 6) with smooth silky white forewings; *Plectophila thrasycosma* Meyr. (pl. 28, fig. 37) with a striking pattern of brown and silver; *Agriophara confertella* Walk. (pl. 30, fig. 3), dull grey and fuscous; and *Lichenaula melanoleuca* Turn. (pl. 28, fig. 38), with forewings a patchwork of black and white. The genus *Catoryctis* (pl. 28, fig. 39) contains species with longitudinally striped forewings; the larvae feed on she-oaks (*Casuarina*). *Scieropepla typhicola* Meyr. is common to Australia and New Zealand.

Family 21. **Gelechiidae** [Aus. 438, N.Z. 22]. Head smooth; antennae rarely with basal pecten; maxillary palpi vestigial or absent; labial palpi long, curved, ascending, sickle-shaped, seg. 3 slender, acute; hind tibiae usually rough-haired. Forewings with R_4 and R_5 stalked or coincident. Hindwings usually broader than forewings, termen sinuate or emarginate, $Sc+R_1$ approximated or connected with basal cell towards base, Rs and M_1 nearly always approximated at base or stalked. The larvae usually feed among spun leaves or shoots. A very large family of small moths, well represented in Australia, but poorly so in New Zealand. Except for the species of *Crocanthes* (pl. 28, fig. 40) which are yellow or orange, marked with red, purple or black, these moths are inconspicuously coloured. The large genus *Protolechia* (pl. 28, fig. 41) replaces *Gelechia*, of which only a few species occur. The species of *Dichomeris* rest on the ground, in Queensland, *D. capnites* Meyr., 18 mm. in expanse, with dark fuscous wings finely spotted with black, sometimes occurs in countless numbers on saplings; no less than 710 specimens were collected off two large leaves on one occasion. In the group of genera including *Epiphthora*, *Aristotelia* and *Thiotricha*, the hindwings have peculiarly emarginate hind margins with produced apices, a formation found in no other family. *Platyedra gossypiella* Saund. is a widely distributed pest of cotton; its larva is known as the "pink boll-worm". In the northern parts of Australia it feeds in the fruit capsules of various species of native Hibiscus, as well as in those of the introduced cotton plant. The Potato Moth, *Phthorimaea operculella* Zell. (=*Lita solanella* Bd.) is an introduced pest of potatoes, tomatoes and tobacco in both countries, while the Angoumois Grain Moth, *Sitotroga cerealella* Ol., is an introduced grain pest in Australia.

Family 22. **Elachistidae** [Aus. 328, N.Z. 24]. Head smooth; maxillary palpi vestigial or absent; labial palpi usually moderate or long, upcurved or sickle-shaped, but sometimes short and drooping. Forewings with one or two veins often absent. Hindwings lanceolate or linear, with long fringes; Rs and M_1 approximated, stalked or coincident, with one or more veins often absent, the base of the cell often open. Larvae usually leaf-miners, or living in seeds or stems, sometimes case-bearing, rarely among spun leaves.

Meyrick has lately divided this large family into Cosmopterygidae, Elachistidae, Scythridae, Coleophoridae, Epermeniidae, etc.; but until the limits of these become clearly defined, it seems wiser to adhere to his older definition.

The large genus *Syntomactis* is peculiar to Australia and New Zealand; it has scale-tufts on forewings and feeds on Myrtaceae; *S. macrostola* Turn., 20-23 mm. in expanse, has black forewings with grey longitudinal stripes. Some very pretty Australian species are found in the genera *Cosmopteryx*, *Limnoecia* and *Labdia*; the last named contains numerous species; *L. deliciosella* Walk. has yellow forewings with black apex; its larva feeds on figs. *Pyroderces terminella* Walk. is a very common species with mottled brown forewings; *P. anaclastis* Meyr. was bred from the nests of the social wasps *Ropalidia* in Queensland. *Elachista* (pl. 28, fig. 42) occurs in both countries, and two of the species are common to both. The other New Zealand species belong mostly to Australian genera, several species being common to both countries; the principal genera are *Batrachedra*, *Proterocosma* and *Lysiphragma*.

Section Tortricites

In this group the maxillary palpi are always vestigial or absent, the labial palpi (fig. Z26) have the distal segment short, cylindrical and obtuse, and the hindwing is never very narrow, usually as wide as, or wider than, the forewings.

Family 23. **Chlidanotidae** [Aus. 3. N.Z. 0] Forewings with Cu_{1a} arising from before three-fourths of basal cell. R_3 and R_4 stalked or coincident; hindwings without cubital pecten. M_2 parallel to M_1. *Rs* and M_1 stalked. A small

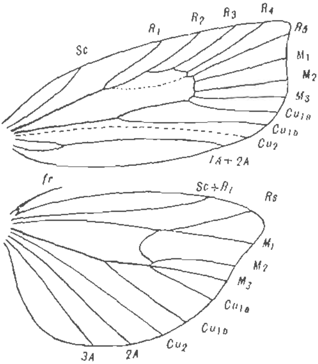


FIG. Z30. Wing-venation of *Tortrix excessana* Walk., New Zealand. Fam. Tortricidae. Lettering as in fig. A8, p. 22, except *fr.* frenulum. [*A. Philpott del.*

Oriental family with two genera, *Epirrhoeca* and *Trymaltis*, found in Queensland. *T. optima* Meyr. (pl. 33, fig. 7), expanse 15-22 mm., has forewings whitish with brown markings, hindwings buff.

Family 24. **Eucosmidae** [Aus. 165, N.Z. 11]. Forewings with Cu_{1b} arising from before three-fourths of basal cell; hindwings with cubital pecten. A large family, not so well represented in our region as elsewhere. *Spilonota* and *Acroclita* are large Australian genera, the former also has 7 species in New Zealand; of these *S. contactella* Walk. is a prettily marked, grey and whitish species; the Australian *A. trimerodana* Meyr. (pl. 28, fig. 43) is a handsomely marked, brown species with dull fulvous hindwings. *Argyroploce* and *Laspeyresia* are large northern genera; most of the former feed in the pods of wattles (*Acacia*); *A. miltographa* Meyr. (pl. 28, fig. 44) and *A. illepida* Butl. are well-known brown species, the latter extending from India to Australia. *Laspeyresia* contains a number of pretty species; *L. sapyrana* Meyr., abundant in grass, has a dark forewing, hindwing orange with dark border; *L. hemicosma* Low. and *L. exemplaris* Meyr., have forewings bright yellow and brown; *L. martia* Meyr., and *L. aurantica* Pryer are lovely insects with bright red scaling on the forewings. *L.* (*Cydia*) *pomonella* L., the well-known Codling-moth, is a serious introduced pest in apples in both countries. *Eucosma plebeiana* Zell., a dull, speckled brown species expanding 15 mm., is a world-wide pest on cultivated Malvaceae. *Polychrosis botrana* Sch. M., smaller and more prettily marked, is a widespread pest on grape vines.

Family 25. **Tortricidae** (Bell Moths, Leaf-rollers) [Aus. 299, N.Z. 102]. Forewings with Cu_{1b} from before three-fourths of basal cell; hindwings without cubital pecten. Larvae leaf-rollers. A large family, but only in Australia and New Zealand outnumbering the Eucosmidae. The world-wide genus *Tortrix* has 100 Australian and about 24 New Zealand species, two or three being common to both countries. Of the Australian species, *T. desmotana* Meyr. (pl. 28, fig. 45) and *T. tasmaniana* Walk. (pl. 28, fig. 46) have brown forewings banded with silver and pale yellow respectively; *T. crysibodes* Turn. has grey forewings, *T. postvittana* Walk. is a common, variably marked, yellow and brown species found

in both countries, where its larva is a pest in apple orchards. In New Zealand, the native species *T. excessana* Walk. (pl. 31, fig. 3) are pests of apples, not only damaging the leaves, but gnawing the rind of the fruit; *T. pictoriana* Feld. (pl. 28, fig. 47) is a handsome mountain species. The large genus *Cacoecia* only differs from *Tortrix* in having the labial palpi ascending instead of porrect: *C. australasiae* Lew. is a large and variable Australian species, expanding 20-30 mm., dull speckled brown. *Capua* is another genus abundant in Australia; *C. debiliana* Walk. (pl. 28, fig. 48) is a common greyish species, *C. solana* Walk. an equally common, variable brown species, slightly smaller; *C. isoscelana* Meyr., expanding 12 mm., has handsome, russet brown forewings. *Homona similana* Walk. is a grey-brown species common in Eastern Australia, with a brown, triangular mark on costa of forewing. *Arotrophora* is an endemic Australian genus with labial palpi longer than in *Tortrix*; all the species feed on Proteaceae; *A. arcuatalis* Walk., expanding 20 mm., with fulvous and grey-brown forewings, feeds everywhere in the flower-cones of *Banksia serrata*; the smaller, grey-brown *A. atimana* Meyr. feeds on the Silky Oak (*Grevillea robusta*).

Of the New Zealand genera, next to *Tortrix*, *Harmologa* takes second place with 21 species; *H. amplexana* Zell. (pl. 28, fig. 49) is greyish, *H. sanguinea* Philp. (pl. 38, fig. 4) rich dark reddish brown on forewings. The allied *Gelophaula* contains the rather handsome *G. siraca* Meyr. (pl. 38, fig. 5) and other species. *Proselena* and *Pyrgotis* each have two New Zealand and one Australian species; *Ctenopseustis obliquana* Walk. (pl. 31, fig. 4) is a common leaf-roller pest of apples and many garden plants in New Zealand, and also attacks the fruit of the peach. *Eurythecta* contains a number of very small species, mostly expanding only 8-10 mm.

Family 26. **Phaloniidae** [Aus. 10, N.Z. 0]. Forewings with Cu_{1b} from near angle of cell. Hindwings without cubital pecten, M_2 present, *Rs* running to costa. A family of some size in the Northern Hemisphere, but very poorly represented in Australia: absent from New Zealand. The best known species is the common and rather pretty *Heliocosma incongruana* Walk., expanding 14-18 mm., cream-coloured with grey or reddish, oblique markings on forewings.

Family 27. **Carposinidae** [Aus. 30, N.Z. 12]. Labial palpi often long. Forewings with tufts of raised scales, Cu_{1b} from near angle of cell, M_2 absent; M_1 usually absent or vestigial; if present, then parallel to *Rs*, which runs to apex. The larvae of this small family mostly feed in fruit; sometimes in galls, shoots, bark, or inside leaves. All the latter and most of the former belong to *Carposina*, a genus of mostly inconspicuous, grey insects, though the Queensland *C. smaragdias* Turn. has green forewings and expands an inch. The Australian genus *Bondia* has exceptionally narrow, black forewings; *B. caseata* Meyr. (pl. 28, fig. 51) has the hindwings orange in the male, pale greyish in the female, while *B. nigella* Newm. has them grey in both sexes. In New Zealand, *Carposina adreptella* Walk. has taken to feeding on the buds of blackberry and may help to check the spread of this pest.

Superfamily VI. PTEROPHOROIDEA

This small group appears to be related both to the Pyraloidea and Tineoidea. It agrees with both in having a true areocel in the forewing; it differs from the Pyraloidea in having Cu_2 always persisting distally in forewing, in the absence of Cu_2 of hindwing, and in the absence of any approximation of $Sc+R_1$ to *Rs* beyond the cell in hindwing. It shares with the Tineodidae and Oxychirotidae of the Pyraloidea the primitive character of having M_2 arising separately in both wings. With rare exceptions the wings are deeply cleft into a series of separate plumes, whence arises the popular name of Plume Moths. The legs are long and slender, with long tibial spurs.

Only two families are known, both found in Australia, but one of them, the Orneodidae, absent from New Zealand. They can easily be distinguished as follows:—

Forewings 2-cleft or 3-cleft, rarely entire.	Fam. 28. PTEROPHORIDAE
Forewings 6-cleft.	Fam. 20. ORNEODIDAE

Family 28. **Pterophoridae** (Five-plume Moths) [Aus. 30, N.Z. 19]. Maxillary palpi absent. Forewings with basal half of Cu_2 absent, M_2 usually present; hindwings usually 2- or 3-cleft, rarely entire; Cu_2 and cubital pecten absent, *3A* present.

The pupae are remarkable in keeping the spiny armature of the larvae and in having the pilifers (lateral processes of the labrum) strongly developed (as

also in Pyraloidea and Rhopalocera); seg. 7 of abdomen is movable in the male pupa.

All the Australian and New Zealand species of this rather small family have cleft wings. Many of the species are widely distributed, probably being easily carried great distances by winds. *Sphenarches caffer* Zell. ranges from Australia and the Pacific to India and Africa. There are no endemic genera, most of the species belonging to the widespread genera *Alucita*, *Platyptilia* and *Stenoptilia*. *S. celidota* Meyr. occurs in both countries. In Australia two of the commonest species are *A. aptalis* Walk., creamy white, and *P. emissalis* Walk., brown with darker markings. *A. lacteipennis* Walk. (pl. 33, fig. 8) is a larger species found in North Queensland. In New Zealand, the brownish *A. furcatalis* Walk. is common; the lovely black and white *A. lycosema* Meyr. (pl. 33, fig. 9) is much rarer. *S. zophodactyle* Dup. is a common, cosmopolitan species.

Family 29. **Orneodidae** (Many-plumed Moths) [Aus. 6, N.Z. 0]. Maxillary palpi absent (except in one Oriental genus). Fore and hindwings both six-cleft (except in one Oriental genus); M_2 absent; Cu_2 complete in forewing, absent in hind. A small family, absent from New Zealand. All the Australian species belong to the widespread genus *Orneodes*. *O. phricodes* Meyr. (pl. 28, fig. 52), the best known species, is greyish in colour; its larva feeds in the flowers of both native and cultivated species of *Bignonia*.

Superfamily VII. PYRALOIDEA

In this group the maxillary palpi are usually present but short, the haustellum nearly always present, the labial palpi moderate, seldom long, porrect or ascending; legs long and slender; forewings with a true areocel, as in Tineoidea and Pterophoroidea, R_3 and R_4 usually stalked, M_2 arising usually from lower angle of cell, Cu_2 absent, anal loop large and $2A$ joining $1A$ nearly at right angles (often partly or wholly obsolete) hindwings with Rs usually partially fusing with $Sc+R_1$ soon after origin, or, if not, closely approximated to it beyond cell; M_1 usually arising from upper angle of cell, connate with Rs, M_2 usually arising from lower angle of cell, Cu_2 generally present. The larvae are very variable in habits, mostly living concealed in leaves, making cases, burrowing in stems or twigs, or feeding on lichens; a number feed on dried vegetable or animal refuse, while a few are truly aquatic, constructing cases similar to those of certain caddis-flies. They all have setae of the primitive type and the circlets of crochets on the prolegs complete or only slightly incomplete. The pupae usually have the maxillary palpi present; the pilifers are strongly developed (as in Pterophoroidea and Butterflies), and seg. 7 of abdomen is fixed in both sexes.

With few exceptions, the moths of this group can be at once recognized by the partial fusion of Rs with $Sc+R_1$ in hindwing beyond the cell; this formation occurs nowhere else within the Order except in a few genera of Drepanidae. Excluding the Thyrididae, Tineodidae and Oxychirotidae, there remains a group of closely allied families, six in number, which are united by the possession of a large anal area in the hindwing, with the three veins Cu_2, $1A+2A$ and $3A$ all fully developed. This group may be called the Section Pyralites.

The superfamily is a large one, represented by more than a thousand species in Australia, and over two hundred in New Zealand. The Oxychirotidae are almost peculiar to Australia, the Tineodidae to Australia and India. The families may be distinguished by the following Key:—

1. Hindwings with Cu_2 absent or obsolescent . . . 2
   Hindwings with Cu_2 present. (Section PYRALITES). . . . 4
2. Forewings with M_2 arising equidistant from M_1 and M_3 (rarely absent). . . . 3
   Forewings with M_2 always present, arising nearer to M_3. Fam. 32. THYRIDIDAE
3. Forewings with a single anal vein; hindwings with two anal veins. Fam. 30. TINEODIDAE
   Both wings without anal veins. Fam. 31. OXYCHIROTIDAE
4. Hindwings without cubital pecten.* . . . 5
   Hindwings with strong cubital pecten. . . . 7
5. Haustellum present.† . . . 6
   Haustellum vestigial or absent. Fam. 35. SCHOENOBIIDAE

*A cubital pecten is present in *Vollba* and *Mnesictena* of the Pyraustidae.
†Except in *Aglossa* of the Pyralidae.

6. Forewings with R_5 separate. Fam. 33. PYRAUSTIDAE
Forewings with R_5 stalked with R_3 and R_4. Fam. 34. PYRALIDAE
7. Forewings with R_5 present.* 8
Forewings with R_5 absent. Fam. 38. PHYCITIDAE
8. Labial palpi equal and long in both sexes; maxillary palpi triangularly scaled. Fam. 36. CRAMBIDAE
Labial palpi short in male, long in female; maxillary palpi not triangularly scaled. Fam. 37. GALLERIIDAE

Family 30. **Tineodidae** [Aus. 9, N.Z. 0]. Maxillary palpi present, except in *Tanycnema*. Forewings with all veins separate, or R_3 and R_4 and rarely R_5 stalked; hindwings without cubital pecten, M_2 usually arising equidistant from M_1 and M_3, M_1 separate or connate with *Rs*, which is approximated to, or partially fuses with $Sc+R_1$ beyond cell. A very small family, only known at present from Eastern Australia and India, though probably also present in the mountains of Papua. There are six Australian genera, all monotypic except *Euthrausta* and *Euthesaura*. *Euthesaura carbonaria* Turn. (pl. 28, fig. 53) is mostly black, with very prominent tornus to forewing and the costal margin of hindwing concave at first and then forming a projecting, convex lobe distally.

Family 31. **Oxychirotidae** [Aus. 2, N.Z. 0]. Maxillary palpi present. Wings narrowly lanceolate or two-cleft, with M_2 arising equidistant from M_1 and M_3, or absent, *Rs* fusing strongly with $Sc+R_1$. A very small family, consisting of two isolated, monotypic genera descended from the Tineodidae, and almost confined to Australia. *Oxychirota paradoxa* Meyr.† (pl. 28, fig. 54) has the wings entire, narrowly lanceolate, rich brownish in colour; *Cenoloba obliteralis* Walk., the Four-plume Moth, has each wing divided into two plumes.

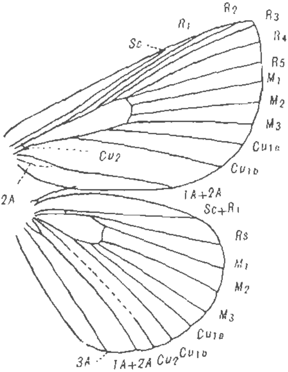


FIG. Z31. Wing-venation of *Striglina scitaria* Walk., Australia. Fam. Thyrididae. Lettering as in fig. A8, p. 22.
[A. Philpott del.

Family 32. **Thyrididae** [Aus. 45, N.Z. 1]. Maxillary palpi absent. Forewings with all veins usually arising separately; hindwings with Cu_2 absent, *Rs* closely approximated to (rarely partially fusing with) $Sc+R_1$ beyond cell. The larvae make tunnels and gall-like swellings in twigs and stems. Most of the species are brownish in colour, with numerous darker strigulations, the pattern being variable. *Striglina* (fig. Z31) contains stout-bodied species, *S. pyrrhata* Walk. (pl. 27, fig. 17) being one of the best known. The allied *Oxycophina*

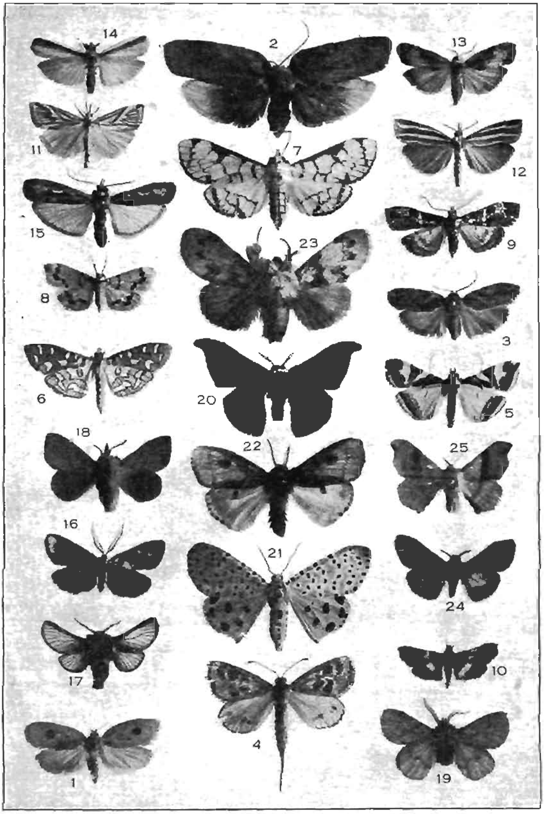
*Except in *Ptochostola* and *Callidia* of the Crambidae.
†Recorded also from Christmas Island, South of Java.

Plate 30

AUSTRALIAN LEPIDOPTERA (Heterocera)

All figures natural size

1. *Machimia pudica* Zell. (Fam. Oecophoridae).
2. *Uzucha humeralis* Walk. (Fam. Xyloryctidae).
3. *Agriophara confertella* Walk. (Fam. Xyloryctidae).
4. *Synemon hesperoides* Feld. (Fam. Castniidae), female.
5. *Margaronia excelsalis* Walk. (Fam. Pyraustidae).
6. *Nausinoë peuritia* Cram. (Fam. Pyraustidae)
7. *Polygrammodes localis* Walk. (Fam. Pyraustidae).
8. *Sylepta clytalis* Walk. (Fam. Pyraustidae).
9. *Pyrausta albistellaris* Hamps. (Fam. Pyraustidae).
10. *Endotricha mesenterialis* Walk. (Fam. Pyralidae).
11. *Talis pleniferella* Walk. (Fam. Crambidae).
12. *Talis bivittella* Don. (Fam. Crambidae).
13. *Heteromicta tripartitella* Meyr. (Fam. Galleriidae).
14. *Emmalocera latilimbella* Rag. (Fam. Phycitidae).
15. *Phycita imparella* Zell. (Fam. Phycitidae).
16. *Pollanisus viridipulverulentus* Guer. (Fam. Zygaenidae).
17. *Doratifera oxleyi* Newm. (Fam. Limacodidae), male.
18. *Entometa australasiae* Fabr. (Fam. Lasiocampidae), male.
19. *Aprosita obscura* Walk. (Fam. Anthelidae).
20. *Neoreta erminea* Warr. (Fam. Drepanidae).
21. *Argina cribraria* Clerck (Fam. Hypsidae).
22. *Lymantria reducta* Walk. (Fam. Liparidae).
23. *Iropoca rotundata* Walk. (Fam. Liparidae), male.
24. *Orgyia anartoides* Walk. (Fam. Liparidae), male.
25. *Panacela lewinae* Lew. (Fam. Bombycidae).



W. C. Davies photo.

AUSTRALIAN LEPIDOPTERA (HETEROCERA)

theorina Meyr., found in North Queensland and Papua, is the giant of the family, expanding up to 60 mm. *Rhodoneura* contains more slenderly built insects. *Addaea* contains smaller species, such as *A. pusilla* Butl. (pl. 28, fig. 55) which have R_4 and R_5 stalked and M_2 of hindwings arising from middle of cell. The New Zealand *Morova subfasciata* Walk., also known from Fiji, is closely allied to *Rhodoneura*; its larva causes fusiform swellings in the stems of the climber *Muehlenbeckia adpressa*. It occurs commonly even as far south as Stewart Island, whereas none of the Australian species, except *S. pyrrhata* Walk., reaches southwards much beyond Sydney.

Section Pyralites

Family 33. **Pyraustidae** [Aus. 456, N.Z. 118]. Maxillary palpi small, filiform or dilated with scales; labial palpi porrect or ascending. Forewings with R_3 and R_4 stalked (except in *Metaprotus*), sometimes R_5 stalked with them. Hindwings with cubital pecten absent (or, rarely, weakly formed), *Rs* fusing partially with $Sc+R_1$.

A very large family with many very widely distributed genera. Most of the Australian species belong to Oriental genera, and many of them even range through the Tropics westward, some reaching as far as Africa. *Voliba, Sceliodes, Metallarcha, Metasia* and a few others are endemic Australian genera; *Clepsicosma, Proteroeca* and *Proternia* are monotypic, endemic, New Zealand genera.

The genus *Heliothela* occurs in both countries; *H. ophideres* Walk. expanding 10 mm., is a pretty Australian species with dark forewings and orange and black hindwings. *Mecyna* is found in Australia, New Zealand, Europe and South America. *M. ornithopteralis* Gn. expanding 25 mm., has rich brown forewings and bright orange hindwings with black border; it is widespread in Eastern Australia, resting on the ground in forest country. *M. maorialis* Feld. (pl. 31, fig. 6) is a smaller New Zealand species with much duller hindwings.

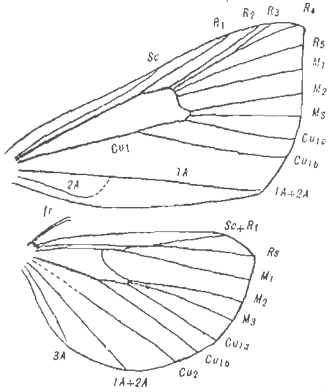


FIG. Z32. Wing-venation of *Pyrausta phoenicialis* Hub., Australia. Fam. Pyraustidae. Lettering as in fig. A8, p. 22, except *fr*, frenulum.
[*A. Philpott del.*

The great genus *Scoparia*, a primitive type with maxillary palpi triangularly dilated with long scales (fig. Z33), is abundantly developed in New Zealand (about 100 species), Hawaiian Islands and Australia (about 40 species). Most of the species are forest insects whose larvae feed on lichens, but in New Zealand a considerable number are found in open grass-lands and superficially resemble Crambids. The moths are protectively coloured; the Australian *S. exhibitalis* Walk. (pl. 28, fig. 56) and the New Zealand *S. aspidota* Meyr. (pl. 38, fig. 6).

S. hemicycla Meyr. (pl. 31, fig. 7), *S. parmifera* Meyr. (pl. 31, fig. 8), *S. trapezophora* Meyr. (pl. 31, fig. 9), *S. trivirgata* Meyr. (pl. 31, 10), and *S. feredayi* Knaggs (pl. 31, fig. 11), are some of the most distinctly marked species.

The genera *Nymphula*, *Cataclysta* and their allies form a group of delicate,

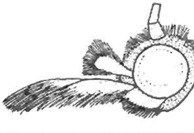


FIG. Z33. Lateral view of head of *Scoparia psammitis* Meyr., showing triangularly dilated maxillary palpi. [*R. J. T. del*

prettily marked species with long slender legs; many of the larvae are aquatic or subaquatic. They are abundant in Australia, but only one species is known from New Zealand. *Nymphula nitens* Butl., expanding 18-25 mm., is a common species in both countries, with forewings mottled brown and grey. In Australia the genus *Cataclysta* contains very handsome species expanding 10-20 mm. The larva of *Hydreuretis tullialis* Walk. is entirely aquatic, living in a large, cylindrical case made of reed stems, and breathing by means of filamentous tracheal gills developed externally on the abdomen; the male moth expands 20 mm., with brown forewings and white hindwings; the female expands 30 mm. with black forewings and fuscous hindwings.

Many of the Australian species are exceedingly handsome, especially in the genera *Agrotera*, *Agathodes*, *Margaronia*, *Hyalobathra* and *Metallarcha*; of such we may mention *Agrotera pictalis* Warr. (pl. 27, fig. 18), *Margaronia suralis* Gn. (pl. 27, fig. 19), the allied clear green *M. atletalis* Walk., the pale blue *M. glauculalis* Gn., *M. canthalis* Walk. (pl. 27, fig. 20), the smaller black and orange-red *M. floridalis* Zell., and *Hyalobathra miniosalis* Gn. (pl. 27, fig. 21). All these are tropical or subtropical species. Of duller colouring, but very pleasing patterns, are *Margaronia excelsalis* Walk. (pl. 30, fig. 5), *Nausinoë pueritia* Cram. (pl. 30, fig. 6) and the large *Polygrammodes localis* Walk. (pl. 30, fig. 7). *Sylepta* is a large genus with many fine species; *S. clytalis* Walk. (pl. 30, fig. 8) feeds on the Kurrajong tree (*Brachychiton*). *Pyrausta* is a very large and widespread genus; *P. ochocalis* Walk. (pl. 27, fig. 22) is one of the handsomest of the Australian species; *P. albistellaris* Hamps. (pl. 30, fig. 9) has dark forewings prettily spotted with white. The genera *Hymenoptychis*, *Tatobotys* and *Bradina* have the abdomen much elongated in the male.

Of economic species, the Cucumber-moth, *Phacellura indica* Saund., white, with broad black borders to wings, is found throughout the Eastern Tropics as far as northern New South Wales; *Dichrocrocis punctiferalis* Gn. is a very widespread pest on maize, and also attacks peaches; it ranges from China, Japan and India well down into Eastern Australia; *Maruca testulalis* Geyer is a widespread species which feeds on beans; and *Nomophila noctuella* Schif. is found in pastures from Europe to Australia. *Hymenia* (*Zinckenia*) *perspectalis* Hub. and *H. fascialis* Cram., expanding about 20 mm., both dark fuscous with whitish fasciae and spots, are circumtropical species found in gardens, where they feed on various Cucurbitaceae; they extend far down into Eastern Australia.

Family 34. **Pyralidae** [Aus. 131, N.Z. 3]. Only differing from the previous family by the forewing having R_5 stalked with R_3 and R_4; Maxillary palpi usually present; hindwing without cubital pecten, and Rs either approximated to or partially fusing with $Sc+R_1$.

This family is smaller than the preceding, but has a greater amount of variation in structure. Most of the genera are widely distributed. *Endotricha* is a large genus with very long shoulder-tufts in the males; *E. mesenterialis* Walk., (pl. 30, fig. 10) from Queensland is sexually dimorphic, with brownish-pink forewings crossed in the male by a pale band; the more southern *E. pyrosalis* Gn. has rich yellow and brown wings in the male, the female being duller. *Macalla* and *Epipaschia* include many species of dull colour, but *E. seminivea* Walk., expanding one inch, is rather handsome, with forewing marbled in dark brown and whitish. *Catachena histricalis* Walk., expanding 20 mm., is dark ochreous, the

forewing with five whitish marks. *Hypsopygia* contains crimson and gold species whose larvae feed in wasps' nests. The finest species belong to the genera *Vitessa, Cardamyla* and *Hypsidea*. *V. glaucoptera* Hamps., expanding 30-40 mm., from North Queensland, has base of forewing orange with black border, middle portion pale grey with black distal spot, apical portion black with veins outlined in pale grey, hindwing grey and black. *C. carinentalis* Walk. (pl. 27, fig. 23) is a very fine species with orange and black hindwing; the smaller *C. didymalis* Walk. has forewing black with white blotches. *H. erythropsalis* Roth., expanding 55 mm., from North Queensland, is the finest Pyraloid in the world; the forewing is grey with a yellow tip and a large white blotch near middle enclosing two blood-red spots, the hindwing yellowish smeared with blood-red.

The subfamily Chrysauginae, with maxillary palpi absent, is represented in Australia by the genera *Drymiarcha, Anemosa* and *Curicta*, the last-named having termen of forewing curiously excavated and lobed.

Of introduced species, the familiar Meal Moth, *Pyralis farinalis* L., is found in both countries; its larva is a pest in stored meal, bran and flour. *P. manihotalis* Gn. is a circumtropical species whose larva feeds on dry stuff about houses in the warmer parts of Australia. Two species of introduced Tabby Moths occur, viz., *Aglossa pinguinalis* L. in Tasmania and *A. cuprealis* Hub. in Queensland.

Family 35. **Schoenobiidae** [Aus. 23, N.Z. 0]. Haustellum absent; maxillary palpi present, usually dilated towards apex; labial palpi porrect. Hindwing without cubital pecten, M_1 connate with *Rs*, and *Rs* partially fusing with $Sc+R_1$.

A small family, absent from New Zealand. The larvae are internal feeders. *Schoenobius* and *Scirpophaga* feed in rushes and sedges; *Sch. imparellus* Meyr. has the male with brown forewing and expanding 20 mm., the female white, expanding 30 mm. *Cirrhoerista rauma* Swin. (pl. 33, fig. 10) is a handsome, white species with dark border to wings. The giants of the group are the four species of *Styphlolepis*, an endemic Australian genus, whose large larvae feed in the stems of small trees and shrubs in dry regions; the brown *S. hypermegas* Turn expands up to 55 mm.

Family 36. **Crambidae** (Grass Moths) [Aus. 112, N.Z. 79]. Maxillary palpi well developed, triangular; labial palpi very long, straight, porrect. Forewing with R_5 present except in *Ptochostola* and *Callidia*; hindwing with strong cubital pecten, *Rs* partially fusing with $Sc+R_1$, M_1 separate or connate with *Rs*.

A fairly large family, well represented in both countries. Most of the species are attached to native grasses. The type genus *Crambus* contains many fine species in New Zealand, and is found at all elevations and under all variations of climate; *C. isochytus* Meyr. (pl. 31, fig. 12) is a fine mountain species, while *C. heliotes* Meyr. (pl. 38, fig. 7) is a small species of unusual colouring, found in moist places. This genus is only represented by a few, mostly insignificant species in Australia; *C. malacellus* Dup. (pl. 33, fig. 11) is a pretty, silver-striped species. The dominant place in Australia is taken by the more archaic genus *Talis*, in which the hindwing has M_1 arising separately. Of the many fine species, mostly with silver-striped forewings, we may mention *T. pleniferella* Walk. (pl. 30, fig. 11), *T. megalarcha* Meyr., *T. bivittella* Don. (pl. 30, fig. 12), and *T. recurvella* Walk.; the last is a lovely Western Australian species with forewings striped in apricot and silver. *T. opulentella* Zell. and *T. crypsichroa* Low. are very common species. *T. leucophthalma* Meyr. is the only known New Zealand species of this genus. *Diptychophora* is well represented by a number of small species in both countries; *D. interrupta* Feld. (pl. 38, fig. 8) is a handsome New Zealand species. *Gadira acerella* Walk. is a peculiar New Zealand species belonging to a monotypic genus. *Orocrambus* is a fine, endemic, New Zealand genus confined to high altitudes; *O. machaeristis* Meyr. (pl. 31, fig. 13) and *O. catacaustus* Meyr. (pl. 31, fig. 14) have dark velvety wings, the forewing with a pale longitudinal stripe. Of other Australian genera we may mention *Chilo, Argyria, Neargyria* and *Ubida*; *A. pentadactyla* Zell. expanding 30 mm., common to South Eastern Australia and New Zealand, has fuscous forewing with whitish longitudinal striae and arrowheads; *N. argyraspis* Meyr. (pl. 33, fig. 12) has a silver forewing margined with brown; *U. ramostriella* Walk. (pl. 33, fig. 13), the largest of the Australian Crambids, has whitish forewings with longitudinal fuscous rays between the veins.

Family 37. **Galleriidae** [Aus. 52, N.Z. 2]. Maxillary palpi present; labial palpi of male short and hidden beneath frontal tuft, those of female long. Forewing with R_5 present; hindwing with strong cubital pecten, *Rs* partially fusing with or approximating to $Sc+R_1$.

A small family of mostly inconspicuous species. *Heteromicta* is the most

PLATE 31

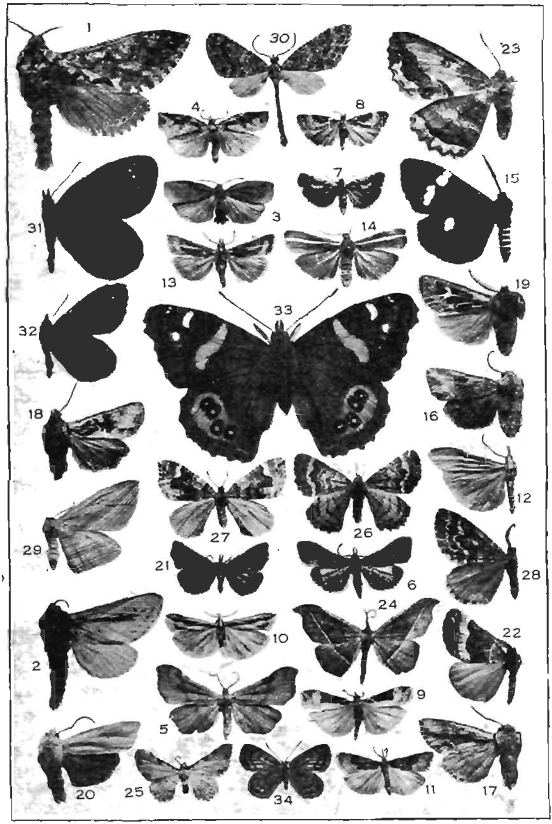
NEW ZEALAND LEPIDOPTERA

All figures natural size

1. *Porina characterifera* Walk. (Fam. HEPIALIDAE).
2. *Porina umbraculata* Gn. (Fam. HEPIALIDAE).
3. *Tortrix excessana* Walk. (Fam. TORTRICIDAE).
4. *Ctenopseustis obliquana* Walk. (Fam. TORTRICIDAE).
5. *Morova subfasciata* Walk. (Fam. THYRIDIDAE).
6. *Mecyna maorialis* Feld. (Fam. PYRAUSTIDAE).
7. *Scoparia hemicycla* Meyr. (Fam. PYRAUSTIDAE).
8. *Scoparia parmifera* Meyr. (Fam. PYRAUSTIDAE).
9. *Scoparia trapezophora* Meyr. (Fam. PYRAUSTIDAE).
10. *Scoparia trivirgata* Meyr. (Fam. PYRAUSTIDAE).
11. *Scoparia feredayi* Knaggs. (Fam. PYRAUSTIDAE).
12. *Crambus isochytus* Meyr. (Fam. CRAMBIDAE).
13. *Orocrambus machaeristis* Meyr. (Fam. CRAMBIDAE).
14. *Orocrambus catacaustus* Meyr. (Fam. CRAMBIDAE).
15. *Nyctemera annulata* Bd. (Fam. HYPSIDAE).
16. *Melanchra rubescens* Butl. (Fam. NOCTUIDAE).
17. *Melanchra paracausta* Meyr. (Fam. NOCTUIDAE).
18. *Melanchra mutans* Walk. (Fam. NOCTUIDAE). female.
19. *Ichneutica dione* Huds. (Fam. NOCTUIDAE).
20. *Leucania sulcana* Fered. (Fam. NOCTUIDAE).
21. *Hypenodes anticlina* Meyr. (Fam. NOCTUIDAE).
22. *Boarmia pungata* Feld. (Fam. BOARMIIDAE).
23. *Boarmia dejectaria* Walk. (Fam. BOARMIIDAE), variety.
24. *Drepanodes muriferata* Walk. (Fam. BOARMIIDAE).
25. *Chloroclystis fumipalpata* Feld. (Fam. LARENTIIDAE).
26. *Dasyuris partheniata* Gn. (Fam. LARENTIIDAE).
27. *Euphyia purpurifera* Fered. (Fam. LARENTIIDAE).
28. *Larentia clarata* Walk. (Fam. LARENTIIDAE).
29. *Venusia verriculata* Feld. (Fam. LARENTIIDAE).
30. *Tatosoma tipulata* Walk. (Fam. LARENTIIDAE).
31. *Erebia merula* Hew. (Fam. NYMPHALIDAE).
32. *Erebia butleri* Fered. (Fam. NYMPHALIDAE).

r. (Fam. NYMPHALIDAE).

m F.B.W. (Fam. LYCAENIDAE).



W. C. Davies photo.

NEW ZEALAND LEPIDOPTERA

prominent Australian genus. *H. latro* Zell. expanding from 30-45 mm., is brown, with a pale longitudinal strip on forewing of male; it is common everywhere, the larvae feeding in the flower-spikes of grass-trees (*Xanthorrhoea*). *H. tripartitella* Meyr. (pl. 30, fig. 13), from Queensland, expands 20-25 mm., the brown forewing with pale grey-blue markings across the disc in the male only. *Tirathaba parasitica* Luc. has larvae which live in the burrows of Hepialidae, and are said to devour their larvae. *Eucallionyma sarcodes* Meyr., expanding 12-20 mm., has ochreous-grey forewings suffused with pink.

Of introduced species, the Wax or Bee Moths, *Galleria mellonella* L. and *Meliphora grisella* Fabr. occur in bee-hives in both countries, while *Corcyra cephalonica* Stn., whose larva feeds on dried fruits and dry animal matter, occurs in Australia.

Family 38. **Phycitidae** [Aus. 194, N.Z. 6]. Maxillary palpi well-developed or vestigial, not triangular; labial palpi ascending or porrect. Forewing with R_5 absent; hindwing with cubital pecten. M_1 connate with *Rs*, and *Rs* partially fusing with, or approximated to $Sc+R_1$.

A large family, most abundant in the tropics. The species are all small and nearly all inconspicuous, but there is much structural variation. The species of *Anerastia* are very abundant, taking the place of Crambids in warm climates, and mostly attached to grasses; they have no haustellum, and are usually pink or grey in colour; *A. virginella* Meyr., expanding 15-25 mm., is a rather pretty Queensland species. *Saluria* and *Emmalocera* are allied genera; *E. latilimbella* Rag. (pl. 30, fig. 14) is one of the prettiest species. *Phycita* and *Nephopteryx* include numerous Australian species which have not yet been carefully worked out; *Ph. imparella* Zell. (pl. 30, fig. 15), from North Queensland, is a large species with brown forewing powdered with greyish-white. *Encryphodes thermochroa* Low., expanding 20 mm., is a rare species from the Northern Territory and Queensland with dark forewing and orange hindwing. *Epicrocis festivella* Zell., expanding 15 mm., and *Etiella walsinghamella* Rag., expanding 18 mm., are the handsomest species; the former has prettily marked, rich brown and ochreous forewing, the latter rich brown and orange forewing. *Homoeosoma vagella* Zell., is a widespread and very common Australian species. *Delogenes limodoxa* Meyr. is the only endemic New Zealand species, belonging to a monotypic genus; the others are stragglers from Australia and elsewhere.

Several important, introduced, economic species occur. The Indian Meal Moth, *Plodia interpunctella* Hub., a world-wide pest on figs, almonds, grocery, etc., is common in Australia but very rare in New Zealand. The Mediterranean Flour Moth, *Ephestia cautella* Walk. (=*E. kuehniella* Zell.), feeding on maize, dry stuff, etc., is found in both countries; several lesser-known species of this genus occur in Australia.

Superfamily VIII. PSYCHOIDEA (ZYGAENOIDEA).

Maxillary palpi obsolete. Tibial spurs short or absent, (occasionally long in Limacodidae), middle spurs often absent. Forewings with areole always absent both in imago and pupa; *M* present within the cell, sometimes simple, but usually branched and enclosing a median cell; M_3 approximated at origin to M_2; Cu_2 complete. Hindwing with *M* present within the cell, but seldom branched; Cu_2 present. Larvae with the setae of specialized form and the crochets of the prolegs not forming complete circlets. Pupae of incomplete type, without maxillary palpi, and with first abdominal spiracles dorsally placed, visible.

This is the first superfamily in which the larvae show specialization of the setae after the first instar; all subsequent superfamilies possess this character. The imagines combine an archaic condition of *M* and Cu_2 with a specialization in the loss of the areole. The three families known in Australia (only one of which, the Psychidae, occurs in New Zealand) may be separated as follows:—

1. Forewings of male with anal veins usually separating distally, *1A* running into Cu_2; female much degraded, wingless. Fam. 39. PSYCHIDAE
   Forewings with anal veins not separating distally, *1A* not connected with Cu_2. 2
2. Haustellum absent; thorax and abdomen more or less stout and hairy; legs more or less hairy. Fam. 41. LIMACODIDAE
   Haustellum present; thorax, abdomen and legs smooth. Fam. 40. ZYGAENIDAE

Family 39. **Psychidae** (Case Moths, Bag Moths) [Aus. 25, N.Z. 2]
Haustellum and palpi absent: antennae in male pectinate to apex; thorax abdomen and legs hairy; hind tibiae without middle spurs; apical spurs short o

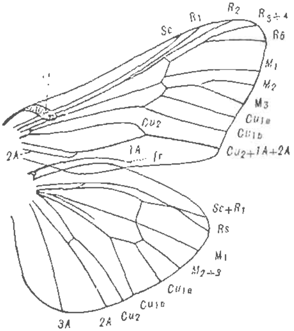


FIG. Z34. Wing-venation of *Clania tenuis* Rosen., Australia. Fam. Psychidae. Lettering as in fig. A8, p. 22, except *fr*, frenulum; *rt*, retinaculum. [*R. J. T. del*

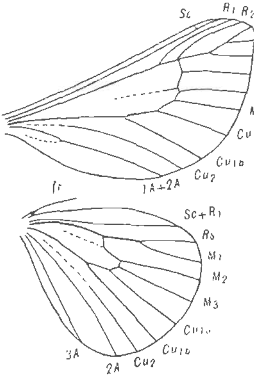


FIG. Z35. Wing-venation of *Doratifera vulnerans* Lew., Australia. Fam. Limacodidae. Lettering as in fig. A8, p. 22. [*A. Philpott del*

absent. Hindwing of male with Sc well separated from cell, free part of R_1 usually present. The larvae construct bags or cases of strong silk into which they weave short twigs or dried leaves. The female is larviform, degraded, and wingless, often never leaving the larval case at all. The males fly with great swiftness, often knocking themselves to pieces in a short time in their efforts to find the females.

A rather small family, most abundant in warm climates. *Oeceticus* is a widespread genus represented in both countries; the New Zealand *O. omnivorus* Fered. is very common, as is also the fine Australian species *O.* (*Metura*) *elongatus* Lew. (pl. 32, fig. 2) in which the long-bodied male has a rich orange head and thorax, and dark wings with pale venation; the elongate fusiform larval cases of this latter species often attain a length of four to five inches, the resulting imagines being females; the males, reared from larvae in smaller cases, are seldom obtained. *Orophora unicolor* Butl. is a much rarer New Zealand species of small size. *Hyalarcta hübneri* Wwd. and *Clania tenuis* Rosen. (fig. Z34) are Australian species with transparent, almost scaleless wings.

Family 40. **Zygaenidae** (Burnet and Forester Moths) [Aus. 16, N.Z. 0]. *Haustellum present; labial palpi short or moderate; tibial spurs short. Forewing with R_3 and R_4 stalked or separate; hindwing with $Sc+R_1$ separate from cell, the free part of R_1 usually present but displaced distally, arising from near middle of cell.*

This moderate-sized family, absent from New Zealand, is found mostly in the tropics. All the Australian species belong to the subfamily Zygaeninae. *Procris* and *Pollanisus* contain a number of rather small species of metallic green, blue or coppery coloration, very similar to the Forester Moths of Europe; one of the commonest is *Pollanisus viridipulverulentus* Guer. (pl. 30, fig. 16). *Hestiochora tricolor* Walk. (pl. 28, fig. 57) has narrower wings and a peculiar colouring, the head and patagia being bright red, the tegulae black, the abdomen black with white rings, the wings fuscous: it is found from Brisbane right across the continent to Perth, and also in Tasmania. *Thyrassia inconcinna* Swin. is a Burnet Moth, closely resembling the Syntomidae

The allied family Chalcosiidae, containing larger, brilliantly coloured, day-
ying, tropical moths, is well represented in the Oriental Region, and it is pos-
ible that one or two species may yet be discovered in the extreme north of
ustralia.

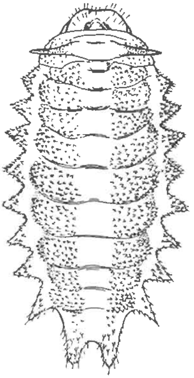


FIG. Z36. Larva of *Susica semicana* Walk., Australia. Fam. Limacodidae. [*A. Tonnoir del.*

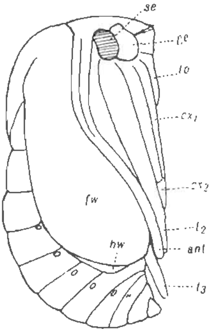


FIG. Z37. Pupa of same. Lettering as in fig. Z15, p. 407, except cx_1, fore coxa; *gc*, glazed eye; *se*, sculptured eye. [*R. J. T. del.*

Family 41. **Limacodidae (Eucleidae, Cochlidiidae or Heterogeneidae)** Cup Moths) [Aus. 35, N.Z. 0]. Haustellum and maxillary palpi absent; tibial purs usually short. Forewing with R_3 and R_4 stalked; hindwing with free part of R_1 sometimes present, but more often replaced by a short fusion between $Sc+R_1$ and cell. Larvae (fig. Z36) slug-like, with prolegs more or less vestigial; etae often developed as stinging hairs. Pupae enclosed in small, rounded or up-like cocoons of hard, smooth silk, opened by means of a circular cap.

A family of moderate size, absent from New Zealand. The best known forms re the species of *Doratifera*, of which *D. vulnerans* Lew. (fig. Z35 and pl. 32, ig. 3), *D. longerans* Lew., and *D. oxleyi* Newm. (pl. 30, fig. 17) are the commonest: the females are larger than, and very different from the males; the arvae are brightly coloured, with large, raised verrucae carrying groups of stinging hairs, and often found feeding on eucalyptus leaves. *Susica semicana* Walk. (pl. 32, figs. 4, 5) feeds on the Waratah (*Telopeia speciosissima*) and other Proteaceae; its curious, broadly oval, slug-like larva (fig. Z36) rests along the midrib of the leaf, where its colouration (green with a median longitudinal yellow stripe) renders it very hard to see. *Susica collaris* Walk. (pl. 33, fig. 14) is a fine, white species which extends far into the dry interior of the continent. *Monopola miltogramma* Meyr. is a handsome red and yellow species found in Queensland. The small *Elassoptila microxutha* Turn. is exceptional in having long labial palpi and long tibial spurs.

Superfamily IX. LASIOCAMPOIDEA

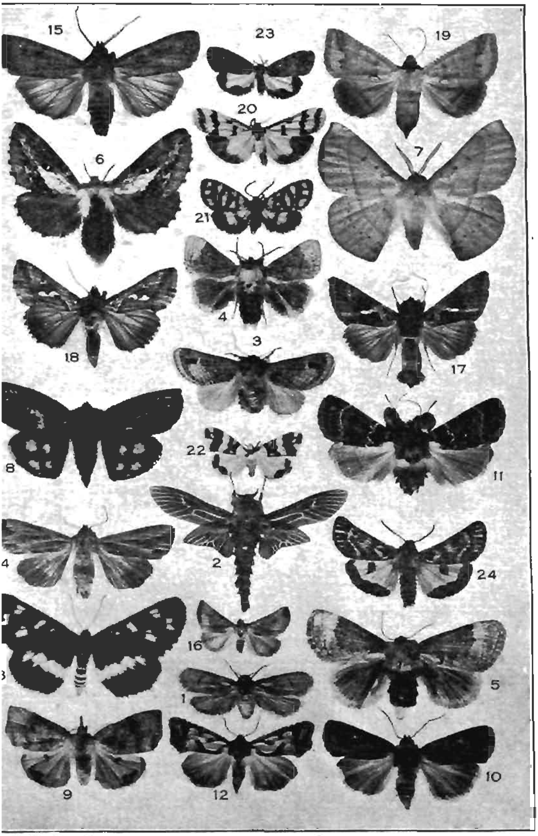
Hindwings with costal area much enlarged basally without frenulum, and having *Sc fused with R_1 which arises from end of cell; or, more often, R_1 is absent,* and then *Sc*, just before origin of *Rs*, fuses for a short distance with *Rs* near its origin, or with *R* before the origin of *Rs*, to form a distinct *subcostal cell* (fig. Z38, *sc*); *Sc* itself gives off before this fusion one or more costal veinlets, usually called *pseudoneuria*. Larvae clothed with soft, woolly hairs; pupa in a compact cocoon.

Plate 32

AUSTRALIAN LEPIDOPTERA (Heterocera)

All figures natural size

1. *Cyclotorna monocentra* Meyr. (Fam. Cyclotornidae).
2. *Oeceticus elongatus* Lew. (Fam. Psychidae).
3. *Doratifera vulnerans* Lew. (Fam. Limacodidae), female.
4. *Susica semicana* Walk. (Fam. Limacodidae), male.
5. *Susica semicana* Walk. (Fam. Limacodidae), female.
6. *Porela vetusta* Walk. (Fam. Lasiocampidae), female.
7. *Anthela acuta* Walk. (Fam. Anthelidae).
8. *Hyblaea constellata* Gn. (Fam. Noctuidae).
9. *Hyblaea ibidias* Turn. (Fam. Noctuidae).
10. *Ariathisa hydraecioides* Gn. (Fam. Noctuidae).
11. *Periphyra sanguinipunctata* Gn. (Fam. Noctuidae).
12. *Cosmodes elegans* Don. (Fam. Noctuidae).
13. *Cruria donovani* Bd. (Fam. Noctuidae).
14. *Persectania ewingi* Wwd. (Fam. Noctuidae).
15. *Agrotis infusa* Bd. (Fam. Noctuidae).
16. *Catoblemma dubia* Butl. (Fam. Noctuidae).
17. *Plusia chalcites* Esper. (Fam. Noctuidae).
18. *Plusia argentifera* Gn. (Fam. Noctuidae).
19. *Pantydia sparsa* Gn. (Fam. Noctuidae).
20. *Lexis alterna* Walk. (Fam. Arctiidae).
21. *Asura lydia* Don. (Fam. Arctiidae).
22. *Castulo gratiosus* Walk. (Fam. Arctiidae).
23. *Halone sinuata* Walk. (Fam. Arctiidae).
24. *Estigmene interfixa* Walk. (Fam. Arctiidae).



C. Davies photo.
AUSTRALIAN LEPIDOPTERA (HETEROCERA)

Family 42. **Lasiocampidae** [Aus. 46, N.Z. 0]. Haustellum and maxillary palpi absent; labial palpi porrect, moderate or long. Thorax and abdomen stout, hairy, legs hairy, tibial spurs short, middle spurs absent. Forewing without areole,

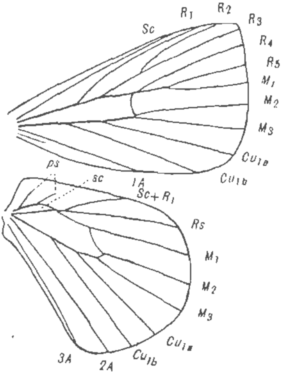


FIG. Z38. Wing-venation of *Porela arida* Walk., Australia. Fam. Lasiocampidae. Lettering as in fig. A8, p. 22; except *ps*, pseudoneuria; *sc*, subcostal cell. [*A. Philpott del*

R_3 and R_4 always stalked, M_2 arising from near lower angle of cell, Cu_2 usually absent.

A family of moderate size, absent from New Zealand, but well represented in Australia. The principal genus is *Entometa*, easily recognized by the long, porrect, labial palpi, forming a prominent "snout". *E. australasiae* Fabr. is a rich brown moth, the male small (pl. 30, fig. 18), the female considerably larger. Some of the species of this genus are large moths with yellowish hindwings. The genus *Porela* contains some handsome grey or brown moths marked with white. *P. vitulina* Don. is a handsome, brown and white species, not uncommon in Eastern Australia, while *P. vetusta* Walk. (pl. 32, fig. 6) is a beautiful, dark grey and white, mountain form. Great sexual dimorphism is shown in the genera *Pinara* and *Crexa*; *P. obliqua* Walk. (pl. 27, fig. 24) has the male with narrow, pointed forewings and dark coloration, the female being much larger, with broader wings and much lighter colouring.

Superfamily X. NOCTUOIDEA

Maxillary palpi vestigial or absent, except in Hyblaeinae. Forewing with areole usually present (absent in Syntomidae), M_2 arising from lower angle of cell, Cu_2 absent. Hindwing with Rs widely separated from $Sc+R_1$ beyond cell (except in Drepanidae), Cu_2 absent, frenulum present (absent in females of Anthelidae). Larvae either smooth or hairy; pupa always a *pupa obtecta*, either in a cocoon or lying free in or on the soil.

This very large group is represented in Australia by eight families, of which only the Hypsidae, Noctuidae, Nolidae and Arctiidae are found in New Zealand. The Anthelidae are an archaic family confined to Australia and Papua. These and the Drepanidae are very distinct groups. The remaining six families form a closely connected complex of forms, between which it is difficult to find reliable family characters; they may conveniently be termed the Section Noctuites. The families may be separated by the following Key:—

1. Forewing with very long areole, the four branches of Rs arising from it separately; a subapical cross-bar from R_1 to or beyond R_2.
   Fam. 43. ANTHELIDAE

   Areole seldom long, branches of Rs never all separate, no subapical cross-bar present. 2

2. Hindwings with Rs approximated to $Sc+R_1$ beyond cell. Fam. 44. DREPANIDAE
Hindwings with Rs not approximated to $Sc+R_1$. (Section NOCTUITES). 3
3. Hindwings with Sc connected with cell between one-fourth and middle of its length. 4
Hindwings with Sc connected with cell near base. 5
4. Haustellum present; thorax and abdomen with smooth scales. Fam. 45. HYPSIDAE
Haustellum absent; thorax and abdomen hairy. Fam. 46. LYMANTRIIDAE
5 Hindwings with $Sc+R_1$ distinct. 6
Hindwings with $Sc+R_1$ absent or fused with Rs. Fam. 50. SYNTOMIDAE
6. Hindwings with Sc either free at base and then fused for a short distance with R, or, more rarely, fused with R as far as middle of cell or less. Fam. 47. NOCTUIDAE
Hindwings with Sc completely fused with R from base to about middle of cell. 7
7 Forewings with raised tufts of scales; scape of antenna with small anterior scale-tuft. Fam. 48. NOLIDAE
Forewings without raised scales; scape of antenna without tuft. Fam. 49. ARCTIIDAE

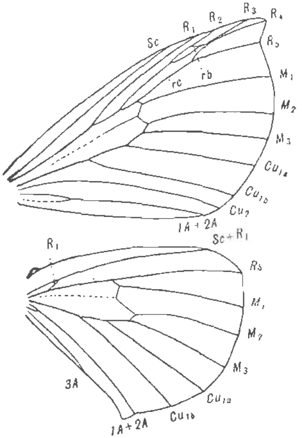


FIG. Z39. Wing-venation of *Anthela acuta* Walk., Australia. Fam. Anthelidae. Lettering as in fig. A8, p. 22, except *rb*, radial cross-bar; *rc*, areole. [*A. Philpott del.*

Family 43. **Anthelidae** [Aus. 52, N.Z. 0]. Haustellum absent, except in *Munichryia*; antennae pectinate to apex in both sexes. Head, thorax, abdomen and femora hairy. Hindwing with basal costal projection, frenulum well developed in male, absent in female, free piece of R_1 present or absent, $Sc+R_1$ usually well separated but sometimes approximated to cell. Larvae very hairy; pupae in silken cocoons, sometimes with larval hairs worked in.

This family is found only in Australia and Papua. Most of the species belong to the genus *Anthela* (fig. Z39), and are fairly large, showy moths with apex of forewing more or less acute, and colour pattern very variable. *A. acuta*

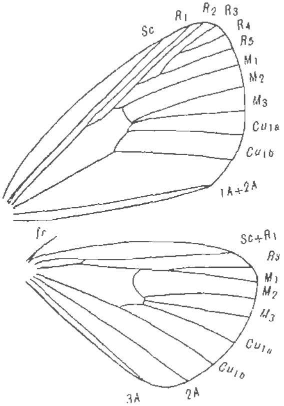


FIG. Z40. Wing-venation of *Lymantria reducta* Walk., Australia. Fam. Lymantriidae. Lettering as in fig. A8, p. 22, except *fr*, frenulum. [*A. Philpott del.*

Walk. (pl. 32, fig. 7) is a very common species of fawn, buff or yellowish coloration with variable pattern; it has a stout, short, hairy, black larva, and a pupa enclosed in a white silken cocoon. *A. oressarcha* Turn. (pl. 35, fig. 2) is a rarer species with beautifully patterned wings. *A. guenéei* Newm. is a peculiar species, blackish with large white spots and a yellow fringe; it mimics the common Hypsid, *Nyctemera amica* Wh. *Nataxa flavescens* Walk. (pl. 27, fig. 25) is a beautiful species of smaller size with the sexes very different; the larger female is dark grey with a white patch about middle of costa of forewing. *Aprosita obscura* Walk. (pl. 30, fig. 19) is grey with two irregular blackish bands across forewing; it is found in the arid regions of Western Queensland. *Pterolocera amplicornis* Walk., expanding 30-50., is very variable in colour; the antennae of the male have very long, delicate pectinations; the female is wingless. The giants of the family are the two species of *Chelepteryx*. *Ch. collesi* Gray (pl. 37, fig. 1) is a rich dark brown, with beautiful zig-zag pattern; the female expands up to six inches. The huge, reddish brown caterpillars feed on Eucalypts, and are covered with urticating hairs, which they work into their cocoons, making them very unpleasant to handle. *Ch. felderi* Turn. is a rarer species; the hindwing is rosy with a castellated black pattern. The genera *Munichryia*, (with a haustellum), and *Gephyroneura* are somewhat anomalous.

Family 44. **Drepanidae** (Hook-tip Moths) [Aus. 3, N.Z. 0]. Labial palpi slender, often minute. Forewing with areole usually present; hindwing with *3A* absent or shortened, M_1 and *Rs* arising from costal margin of cell, *Rs* approximated to $Sc+R_1$ beyond cell; frenulum present or absent.

A small family with a wide range of structural variation, and not closely related to any other. Absent from New Zealand and from the greater part of Australia, but three species are found in North Queensland. *Neoreta erminea* Warr. (pl. 30, fig. 20) is a handsome, rich brown species.

Section NOCTUITES

Family 45. **Hypsidae** [Aus. 14, N.Z. 1]. Haustellum present; head, thorax.

abdomen and femora smooth. Hindwing with frenulum present, *Sc* approximated to and connected with cell before middle, or fusing for a short distance with it at one-third or one-fourth.

A small family directly ancestral to the Arctiidae. Most of the species are tropical or subtropical. The genus *Nyctemera* contains the two very closely allied species *N. amica* Wh., common in Australia, and *N. annulata* Bd. (pl. 31, fig. 15) equally common in New Zealand; they expand 40-45 mm., and have the wings black, with two white blotches on forewing, and one on hind; the abdomen is black with orange rings. They fly by day; their handsome larvae, black and reddish-orange in colour, with a tuft of hairs projecting forward on either side of the head, feed on native species of *Senecio*, and have become a serious pest in gardens, where they destroy Cinerarias and other Compositae. These larvae are distasteful to birds, except Cuckoos. The two species were found to interbreed freely when placed together, the hybrids, both larvae and adults, being intermediate in form and pattern between the two. *Hypsa plagiata* Walk. (pl. 35, fig. 3) is a handsome Queensland species, expanding to 60 mm., with dull brown forewing having the veins and a round blotch pale yellow, hindwing orange and brown. *Argina cribraria* Clerck (pl. 30, fig. 21) is a pretty species with orange wings, heavily spotted; it ranges from Queensland to India and Africa.

Family 46. **Lymantriidae (Liparidae)*** (Tussock Moths) [Aus. 60, N.Z. 0]. Haustellum absent; antennae pectinate to apex in male and nearly always in female also; body and femora hairy. Hindwing with *Sc* approximated to and usually connected with cell between one-third and middle, rarely fusing with it. Larvae very hairy, often with tufts or brushes of hairs, sometimes with urticating hairs, frequently conspicuously coloured and distasteful to birds; many species have gregarious larvae living within a large, bag-like shelter, spun between the twigs and leaves of trees. Pupae in a cocoon, often with larval hairs spun into it.

A fairly large family, absent from New Zealand. The commonest Australian species are those of the genera *Porthesia*, *Euproctis* and *Acyphas*, which are structurally different but superficially very similar, mostly unicolourous white or yellow, some having the abdomen ending in a tuft of brown or yellow hairs. *A. chionitis* Turn. (pl. 33, fig. 15) is the pure white Gold-tail Moth of Eastern Australia. *P. obsoleta* Don. from South-Eastern Australia, is also white, but has a blackish body ending in a brown tuft. *P. lutea* Fabr. (pl. 27, fig. 26) is the most beautiful species, rich yellow in colour. Many of the genera have wingless

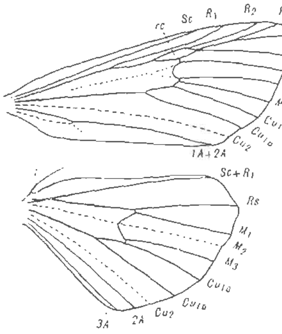


FIG. Z41. Wing-venation of *Melanchra mutans* Walk., New Zealand. Fam. Noctuidae, subfam. Melanchrinae. Lettering as in fig. A8, p. 22, except *fr*, frenulum; *rc*, areole. [*A. Philpott del.*

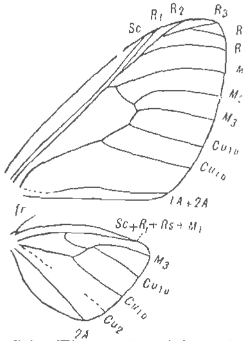


FIG. Z42. Wing-venation of *Syntomis annulata* Fabr., Australia. Fam Syntomidae. Lettering as in fig. A8, p. 22 and Z41; *Sc*+R_1+*Rs*+M_1, the single anterior vein of hindwing formed by fusion of these four veins (M_2 obsolete). [*A. Philpott del*

**Liparis* Ochs. (1810) is preoccupied by *Liparis* Scopoli (1777) a genus of Fishes (originally *Liparis* Artedi, 1738, pre-Linnean).

females, as, for instance, *Iropoca* and *Orgyia*; the male of *I. rotundata* Walk. (pl. 30, fig. 23) has greyish forewing marked with blackish, and dull brown hindwing. *Orgyia anartoides* Walk. (pl. 30, fig. 24) is a garden pest, the larva feeding on geraniums. *Lymantria reducta* Walk. (pl. 30, fig. 22) is a pest on the White Cedar (*Melia Azedarach*) in Eastern Australia.

Family 47. **Noctuidae** [Aus. 884, N.Z. 120]. Haustellum usually well developed; maxillary palpi absent, except in Hyblaeinae; labial palpi moderate or long, ascending or porrect; tibiae with all spurs present. Forewing with areole usually present; hindwing with frenulum present, *Sc* free at base, fusing with *R* for a short distance near base, rarely to about middle, M_2 sometimes absent or imperfect, arising from or below middle of cell, sometimes well developed and from lower angle of cell. Larvae mostly smooth and cylindrical (cut-worms), sometimes with a reduced number of prolegs (semi-loopers); pupae free or in a cocoon.

This is an enormous family, well represented in all parts of the world. Many of the larvae are serious pests on crops and fruit; one or two genera are beneficial, the larvae feeding on scale-insects. Of the numerous subfamilies, the first six mentioned below (Hyblaeinae to Agrotinae) form the group "Trifinae", in which M_2 in hindwing is weakly developed or obsolescent, usually arising from middle of cell, and the larva has the usual number of prolegs; all the rest form the large group "Quadrifinae" in which M_2 of hindwing is strongly developed, arising from or near the lower angle of cell, and the larva is generally a semi-looper (fig. Z11) with prolegs of segs. 3-4 reduced or absent.

The Hyblaeinae are a small subfamily distinguished by the presence of 3-segmented maxillary palpi. Four species of the genus *Hyblaea* occur in Queensland *H. constellata* Gn. (pl. 32, fig. 8) has rich black forewing with patches of pale green scales, hindwing black with four orange blotches; the underside is rich black, orange and rose. The smaller *H. ibidias* Turn. (pl. 32, fig. 9) has brownish forewing and rosy hindwing; when at rest it resembles a withered leaf.

The Acronyctinae are a large group chiefly found in the Northern Hemisphere, not so well represented in Australia, and absent from New Zealand. They have smooth eyes without cilia, and tibiae without spines; most of the species are of ordinary form and dull coloration. *Syntheta smaragdistis* Hamps., with brilliant green forewings, extends from Northern New South Wales to Papua. *Calogramma festiva* Don. is pale yellow, with base of wings marked with red and black; it ranges from Sydney to Queensland and Ceylon, the larva feeding on Liliaceae. Two shining white species of *Chasmina* occur in Queensland. *Eremochroa* is an endemic genus found in the dry interior. *Prodenia litura* Fabr. has strongly marked, brown forewing and nearly transparent, white hindwing. *Ariathisa hydraecioides* Gn. (pl. 32, fig. 10) is a very common, dark brown species with a small white spot on forewing. *Periphyra sanguinipunctata* Gn. (pl. 32, fig. 11) has rich, velvety blackish forewings and exceedingly woolly forelegs. *Cosmodes elegans* Don. (pl. 32, fig. 12), a very common but beautiful species, has rich bronze-brown forewings with irregular areas of bright green; this species is also taken in New Zealand.

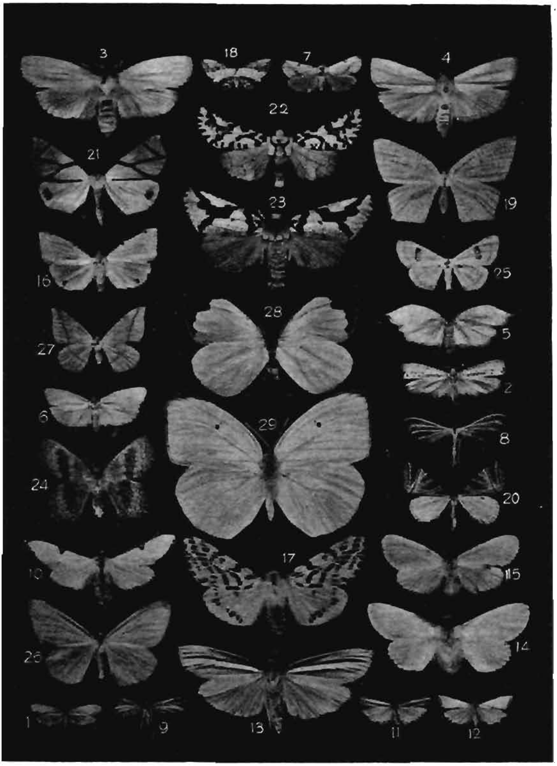
The Agaristinae are large, day-flying moths, mostly having the antennae more or less dilated before the apex. They are a direct development from the Acronyctinae and with difficulty separable from them. Absent from New Zealand; the Australian species are few in number, though conspicuous. The larvae are conspicuously marked, and carry single hairs or setae. *Agarista agricola* Don., expanding 3 inches, is the largest and gaudiest species; the forewings are black, with blue, yellow and orange blotches, the hindwing black with a white termen and red and blue blotches in the middle; it ranges from Sydney to Papua and Timor. *Comocrus behri* Angas (pl. 36, fig. 1) is a handsome, black moth with irregular white fasciae on the wings. *Cruria donovani* Bd. (pl. 32, fig. 13) is a smaller, black species with creamy spots and band, quite common in Eastern Australia. The Vine Moth, *Phalaenoides glycinae* Lew., is the commonest species of all; it somewhat resembles the previous species, but the hindwings are without markings and the forewings have a transverse band and small blotch of pale yellow. The larva is a serious pest on vines. The Whistling Moth, *Hecatesia fenestrata* Bd. (pl. 27, fig. 28) is an extraordinary insect, in which the forewing of the male has a strong, chitinous projection of the costa with a large, ribbed, hyaline, subcostal area; a peculiar whistling sound is produced as the moth makes its curious, circling flight about sunset. The females are voiceless and have normally shaped and scaled forewings. It is noteworthy that the hyaline area of the male is also thickly clothed with scales when the moth first emerges. The

Plate 33

PALE SPECIES OF AUSTRALIAN AND NEW ZEALAND LEPIDOPTERA

All figures natural size

1. *Narycia palleuca* Meyr. (Fam. TINEIDAE), Aus.
2. *Hyponomeuta myriosemus* Turn. (Fam. HYPONOMEUTIDAE), Aus.
3. *Cryptophasa nymphidias* Turn. (Fam. XYLORYCTIDAE), Aus.
4. *Cryptophasa flavolineata* Walk. (Fam. XYLORYCTIDAE), Aus.
5. *Eschatura lemurias* Meyr. (Fam. XYLORYCTIDAE), Aus.
6. *Neodrepta luteotactella* Walk. (Fam. XYLORYCTIDAE), Aus.
7. *Trymaltis optima* Meyr. (Fam. CHLIDANOTIDAE), Aus.
8. *Alucita lacteipennis* Walk. (Fam. PTEROPHORIDAE), Aus.
9. *Alucita lycosema* Meyr. (Fam. PTEROPHORIDAE), N.Z.
10. *Cirrhochrista rauma* Swin. (Fam. SCHOENOBIIDAE), Aus.
11. *Crambus malacellus* Dup. (Fam. CRAMBIDAE), Aus.
12. *Neargyria argyraspis* Meyr. (Fam. CRAMBIDAE), Aus.
13. *Ubida ramostriella* Walk. (Fam. CRAMBIDAE), Aus.
14. *Susica collaris* Walk. (Fam. LIMACODIDAE), Aus.
15. *Acyphas chionitis* Turn. (Fam. LIPARIDAE), female, Aus.
16. *Castulo nivosus* Walk. (Fam. ARCTIIDAE), Aus.
17. *Ardices glatignyi* Le Guil. (Fam ARCTIIDAE), Aus.
18. *Epiplema instabilata* Walk. (Fam. EPIPLEMIDAE), female, Aus.
19. *Aploschema discata* Warr. (Fam. URANIIDAE), Aus.
20. *Epidesmia replicataria* Walk. (Fam. OENOCHROMATIDAE), Aus.
21. *Thalaina clara* Walk. (Fam. BOARMIIDAE), Aus.
22. *Declana atronivea* Walk. (Fam. BOARMIIDAE), N.Z.
23. *Declana egregia* Feld. (Fam. BOARMIIDAE), N.Z.
24. *Eucyclodes pieroides* Walk. (Fam. GEOMETRIDAE), male, Aus. (female, pl. fig. 13).
25. *Problepsis saucta* Meyr. (Fam. STERRHIDAE), Aus.
26. *Venusia praefectata* Walk. (Fam. LARENTIIDAE), N.Z.
27. *Larentia pseudostenaria* Huds. (Fam. LARENTIIDAE), N.Z.
28. *Elodina angulipennis* Luc. (Fam. PIERIDAE), Aus.
29. *Catopsilia pyranthe pythias* W. & L., form *lacteola* (Fam. PIERIDAE), Au



I. C. Davies photo.
PALE SPECIES OF AUSTRALIAN AND NEW ZEALAND LEPIDOPTERA

larva feeds on the Dodder (*Cassytha*). Two other, rarer species of this genus are known. The Cuculliinae have long cilia overhanging the eyes; there are but few Australian species, and none in New Zealand

The Melanchrinae, with hairy eyes, are the dominant group in New Zealand, where the great genus *Melanchra* is represented by more than fifty species. Most of these are dull coloration, but *M. meyricki* Hamps. (pl. 38, fig. 9) and *M. maya* Huds. (pl. 38, fig. 10) are alpine species of fine colouring. Other well marked species are *M. rubescens* Butl. (pl. 31, fig. 16), *M. paracausta* Meyr. (pl. 31, fig. 17) and *M. coeleno* Huds. The larvae are typical cutworms, and at times do considerable damage to crops. The commonest species is *M. mutans* Walk. (pl. 31, fig. 18) in which the forewings are reddish brown in the male, grey in the female. *Ichneutica* is an allied genus peculiar to New Zealand, containing two fine alpine species, *I. ceraunias* Meyr. (pl. 38, fig. 11), and *I. dione* Huds. (pl. 31, fig. 19). *Persectania steropastis* Meyr. is a pest of Native Flax (*Phormium tenax*), the larva cutting V-shaped incisions in the leaf-blades, and shortening the length of fibre obtainable. *P. ewingi* Wwd. (pl. 32, fig. 14), common also in Australia, has been called the "New Zealand Army-worm"; it sometimes appears in enormous numbers and completely destroys large areas of wheat and grass. The widespread genus *Leucania* has a number of very closely similar species in New Zealand, all with buff or pale brown forewings, the finest being *L. purdici* Fered.; *L. sulcana* Fered. (pl. 31, fig. 20) is considerably smaller. *Erana graminosa* Walk. (pl. 38, fig. 12) is a pretty greenish species found in forests, its larva feeding on the Mahoë (*Melicytus ramiflorus*). The Australian representatives of this subfamily are few, chiefly belonging to the genus *Aletia*.

The widespread *Cirphis unipuncta* Haw. and *Heliothis obsoleta* Fabr. occur in both countries. The larva of the former is known in America as the "Army Worm"; it attacks grass and crops of all kinds, and is occasionally a serious pest in Australia. The larva of *H. obsoleta* feeds on maize, peas, tobacco, cotton, etc., and is known in America as the "Cotton Boll Worm" or "Corn Ear Worm", it is one of the most serious pests of cotton known.

The Agrotinae closely resemble the previous group, but have naked eyes. Few species occur in either country, but some of them are very common. *Agrotis infusa* Bd. (=*spina* Gn., pl. 32, fig. 15), the Australian Bugong or Bogong Moth, frequently appears in countless numbers on the Southern Alps, and, in dry seasons, along the Eastern coast-line; it sometimes swarms in Sydney, where it may become a nuisance in houses. This moth was an important article of food for the aborigines, who made a kind of dough or paste from the bodies. It sometimes flies on board ships far out on the Tasman Sea, and is also taken in New Zealand, where, however, it is by no means common. An allied species, *A. ypsilon* Rott., is common in both countries, and a number of other species are also recorded. The larvae are typical cut-worms, and at times do a great deal of damage.

The Sarrothripinae are mainly a tropical group and are well represented in Queensland; 53 Australian species are known. The larvae have all prolegs present and are sparsely covered with hair. *Sarrothripus* and closely allied genera contain small, protectively coloured species somewhat resembling Tortricites in appearance. The endemic genus *Calathusa* contains a number of species with more elongate wings. The genera *Blenina*, *Plotheia*, *Gadirtha* and *Eligma* contain larger species; *E. orthoxantha* Low. has the forewings grey with dark dots and whitish lines, the hindwings fuscous with dorsal edge orange, and the abdomen orange with blackish spots.

Passing by the Stictopterinae and Euteliinae, each of which is represented in Queensland, we next come to the Erastriinae, which form an annectent group between the "Trifinae" and "Quadrifinae". They are of small size, mostly with the venation somewhat reduced, and the larvae are semi-loopers. They are well represented in the warmer parts of Australia, with few species in the south, and none in New Zealand. The genus *Catoblemma* is beneficial, its larvae devouring scale-insects. *C. dubia* Butl. (pl. 32, fig. 16) occurs in Victoria.

The Acontiinae are a small, tropical group, best represented in Queensland; they have smooth forewings and usually a bar-shaped retinaculum in the male. *Earias* and allies have the subcostal retinaculum of the male entirely absent, the wing-coupling taking place by means of a subdorsal retinaculum, as in the female. *E. smaragdina* Butl. (pl. 27, fig. 27) is a pretty green species; the larva of the allied *E. huegeli* Rogen., a species with creamy-white forewings blotched with green, is a pest of cotton.

The Plusiinae, with ciliated eyes and semi-looper caterpillars (fig. Z11), are represented in both countries by widespread species of the genus *Plusia*. *P. chal-*

cites Esper (pl. 32, fig. 17), known as the Silver-Y Moth in New Zealand, is an Old World species, common in both countries, its larva feeding on many garden plants and herbs, especially Solanaceae, and sometimes damaging tomatoes by boring into the green fruit. *P. oxygramma* Hub. also occurs in both countries, *P. argentifera* Gn. (pl. 32, fig. 18), known as the Silver-Y Moth in Australia, is very common there; its larva behaves very similarly to that of *P. chalcites*.

The Noctuinae (including the Catocalinae, which only differ by the presence of spines on the middle tibiae) are a large group chiefly represented in the Tropics; they include some of the smallest and the largest species in the family. The larvae are mostly semi-loopers. The group is not represented in New Zealand, except by introduced species. The Orange-Suckers are large, handsome moths belonging to the genus *Ophideres*, with very strong, gimlet-like haustellum; in Queensland they are sometimes destructive to fruit, especially oranges and bananas. *O. salaminia* Fabr. (pl. 35, fig. 4) has rich green forewing with pale bands along costa and termen, hindwing orange with black border and black lunule. *O. fullonica* L. is somewhat larger, the forewing mottled with brown, grey and olive-green, the hindwing rich orange with broader black border and larger lunule. *O. materna* L. has paler forewing, the hindwing orange with less black on it, and the lunule replaced by a small round spot. The genus *Donuca* includes the handsome *D. rubropicta* Butl. (pl. 35, fig. 5) with richly marked brown wings and abdomen partly rose-red; the forewings have an oblique, white stripe and a large eye-spot: *D. lanipes* Butl. has less richly marked forewing with a broader white stripe touching the eye-spot, and abdomen partly yellow. Both species are found in Queensland. The genera *Dasypodia* and *Sericea* contain large, dark brown species with beautifully waved markings on wings. *D. selenophora* Gn. expands about 3 inches, and has a large eye-spot on forewing, steel-blue in centre, margined with black and orange; it is common in Victoria and Tasmania, and not uncommon in parts of New Zealand; its larva feeds on wattles. *S. spectans* Guer. (pl. 36, fig. 2), very common around Sydney, is somewhat larger, with a larger eye-spot on forewing, and a smaller eye-spot near tornus of hindwing; it has also been taken in New Zealand, though very rarely. Both these moths fly into houses, resting on the walls with outspread wings. The genus *Niguza* inhabits the arid regions of Western Queensland; *N. eucesta* Turn. has the wings peculiarly ornamented. *Parallelia propyrrha* Walk. expanding 40-50 mm., has rich orange thorax, dark brown forewing and black hindwing, both with white termen. *Achaea janata* L. (=*melicerta* Dr., pl. 35, fig. 6) is a Queensland species whose larva feeds on the castor-oil plant (*Ricinus*). *Tantydia sparsa* Gn. (pl. 32, fig. 19), greyish with slight pattern on forewing, occurs round Sydney. The genus *Rhapsa* contains curious, brownish species with naked eyes and long, obliquely ascending palpi; it occurs in both countries. *Rh. scotosialis* Walk., expanding 30-35 mm., is very common in New Zealand; its larva feeds on Kawakawa (*Macropiper excelsum*); though it has the full number of prolegs, it progresses like a semi-looper.

The Hypeninae or Deltoid Moths have the labial palpi (fig. Z43) acute, often very long, straight or sickle-shaped, and rest with the wings forming a triangle;

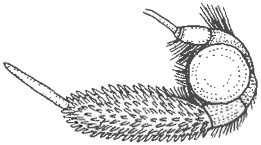
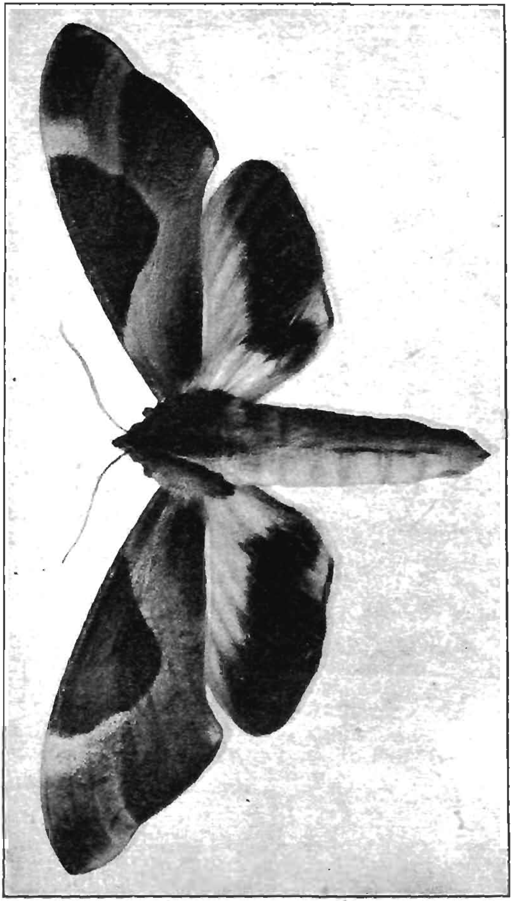


FIG. Z43. Lateral view of head of *Hypenodes anticlina* Meyr., New Zealand (x 16). Fam. Noctuidae, subfam. Hypeninae. [*R. J. T. del.*

the larvae are semi-loopers. Species of *Hypenodes* occur in both countries; *H. costistrigalis* Steph. ranges to Asia and Europe; *H. anticlina* Meyr. (pl. 31, fig. 21), an endemic New Zealand species, has a more definite pattern than most of them, the usual colouring being dull brownish with very little definite markings.

Family 48. **Nolidae** [Aus. 42, N.Z. 1]. Scape of antennae with small anterior tuft; labial palpi moderately long, porrect; tibiae with all spurs present.

Plate 34



W. C. Davies photo.

Coequosa triangularis Don. (Fam. SPHINGIDAE), female. (Natural size.)

Forewings with raised tufts of scales, areole absent. Hindwings with frenulum present, M_2 arising from or near lower angle of cell, *Sc* fusing with cell from base to near middle. This small family is structurally very close to the Arctiidae. The species are small and dull in colouring; *Nola* and *Celama* contain most of them. *Zia tactalis* Walk. is the largest species. *Roeselia lugens* Walk. (pl. 39, fig. 1) is a greyish-brown species found round Sydney. The only New Zealand species is the rare *Celama parvitis* Howes.

Family 49. **Arctiidae** (Tiger Moths) [Aus. 168, N.Z. 4]. Forewings smoothly scaled, areole sometimes present; hindwings from M_2 arising from near lower angle of cell; *Sc* fused with cell from or near base to about middle, frenulum present, retinaculum of male nearly always bar-shaped. Larvae very hairy.

This large family falls naturally into two subfamilies, the Lithosiinae and Arctiinae, the latter being larger and of stouter build than the former. Most of the Australian species belong to the Lithosiinae, with many endemic genera. *Lambula*, *Ilema* and *Lexis* contain species of medium size and mostly dull coloration, but *Lexis alterna* Walk. (pl. 32, fig. 20) is prettily marked with dull orange and black. *Asura* and *Castulo* contain mostly brightly coloured species, orange and black being the predominating pattern. *Asura lydia* Don. (pl. 32, fig. 21) is a handsome species found in Eastern Australia. *Castulo shepherdi* Newm. (pl. 27, fig. 29) and the allied *C. gratiosus* Walk. (pl. 32, fig. 22) are very handsome species, while *C. nivosus* Walk. (pl. 33, fig. 16) is exceptional in being almost pure white. *Halone sinuata* Walk. (pl. 32, fig. 23) is a common species with dark forewings, and hindwings deep orange with black termen. *Scoliacma bicolor* Bd. (pl. 27, fig. 30) is a common but very beautiful species which folds its rather narrow forewings in the manner of the European "Footmen Moths"; but its livery is gayer than theirs. The genera *Thallarcha*, *Philenora* and allies contain very small but beautifully marked species. The widespread Crimson Speckled Moth, *Utethesia pulchella* Hub. occurs both in Australia and the North Island of New Zealand. In the Arctiinae, the genus *Metacrias* contains three very beautiful, alpine, New Zealand species, the finest of which is *M. erichrysa* Meyr. (pl. 38, fig. 13); the females in this genus are subapterous. *Estigmene* is a closely allied genus found on the Southern Alps of Australia and in Tasmania; *E. interfixa* Walk. (pl. 32, fig. 24) is rich orange and black in colour, with deep red on abdomen and base of costa of forewings. The true Australian Tiger-Moths are few in number, the wings mostly white with dark spots and the body often red. *Ardices glatignyi* Le Guil. (pl. 33, fig. 17) is a very common and typical species. The larva is a typical "Woolly Bear," reddish brown in colour and very hairy.

Family 50. **Syntomidae (Amatidae)** [Aus. 52, N.Z. 0]. Haustellum usually well-developed. Forewing with areole absent; hindwing small, with *Sc* completely fused with *R* and *Rs*, frenulum present, retinaculum of male bar-shaped.

This large family is principally represented in South America, and is mostly tropical. Most of the Australian species belong to the large genus *Syntomis* (*Amata*); they have banded abdomens and dark wings, the forewings marked with oval, orange or yellowish spots, giving them a superficial resemblance to the Burnet Moths of the family Zygaenidae. *Syntomis annulata* Fabr. (pl. 27, fig. 31) is one of the commonest species. The species of this genus are all much alike and difficult to distinguish. *Euchromia* is a genus of large and more brilliantly coloured species found in the Oriental Region; a few of its species occur in the far north of Australia.

Superfamily XI. URANIOIDEA

Haustellum present; maxillary palpi absent. Forewings without areole, Cu_2 absent, R_5 well separate from R_4 and usually stalked with M_1, M_2 arising from middle of cell. Hindwings with Cu_2 absent, *Sc* free basally, M_2 arising from middle of cell. There are only two families, easily separated as follows:—

Frenulum present.	Fam. 51. EPIPLEMIDAE
Frenulum absent.	Fam. 52. URANIIDAE

Family 51. **Epiplemidae** [Aus. 22, N.Z. 0]. Hindwings rounded, or with slight projections on *Rs* and M_3, costal area not enlarged basally, *3A* absent.

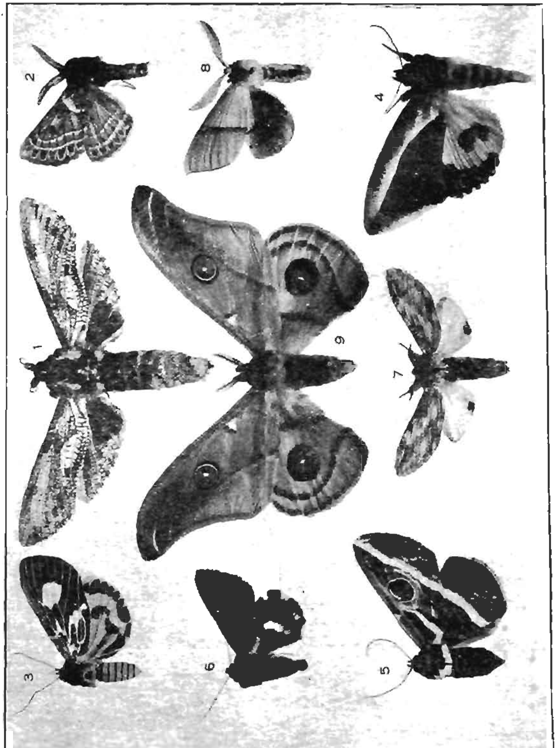
A small family with inconspicuous species, found along the warmer portion of the Eastern coast of Australia. The hindwings of the two sexes differ in shape. These moths rest with their wings rolled up, the forewings stretched well out and the hindwings close to the body, in this position they resemble spiders, the habit being protective. Of the nine species of *Epiplema*, *E. instabilata* Walk.

PLATE 35

AUSTRALIAN LEPIDOPTERA (HETEROCERA)

All figures natural size

1. *Xyleutes donovani* Roth. (Fam. COSSIDAE), male.
2. *Anthela oressarcha* Turn. (Fam. ANTHELIDAE).
3. *Hypsa plagiata* Walk. (Fam. HYPSIDAE).
4. *Ophideres salaminia* Fabr. (Fam. NOCTUIDAE).
5. *Donuca rubropicta* Butl. (Fam. NOCTUIDAE).
6. *Achaea janata* L. (Fam. NOCTUIDAE).
7. *Hoplitis cydista* Turn. (Fam. NOTODONTIDAE).
8. *Gastrophora henricaria* Gn. (Fam. OENOCHROMATIDAE).
9. *Antheraea eucalypti* Sc. (Fam. SATURNIIDAE).



W. C. Davies photo.

(pl. 33, fig. 18) is the most striking, strongly speckled in brown and white. *Balantiucha decorata* Warr. (pl. 28, figs. 58, 59) has a white patch on the hindwings which renders them partially invisible when folded, thus greatly increasing

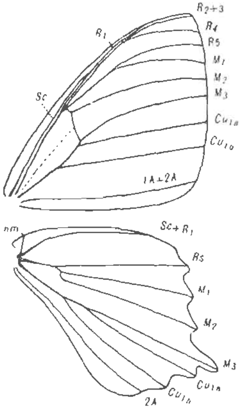


FIG. Z44. Wing-venation of *Alcidis zodiaca* Butl., Australia. Fam. Uraniidae. Lettering as in fig. A8, p. 22. [*A. Philpott del.*

the resemblance to a spider. *Lobogethes interrupta* Warr. (pl. 28, figs. 60, 61) has the anal portion of the hindwings white, and, when at rest, rolls its wings completely up.

Family 52. **Uraniidae** [Aus. 11, N.Z. 0]. Hindwings with costal area greatly expanded basally; *Sc* sometimes with a humeral veinlet, usually a tail or angle developed on M_3; *3A* absent.

A small tropical family only represented along the Queensland coast. The commonest species is the large and handsome, day-flying moth, *Alcidis zodiaca* Butl. (pl. 36, fig. 3), velvety black and olive green in colour, which is sometimes to be seen swarming in great numbers on the lianas of the dense tropical jungle. The large, tailed *Nyctalemon patroclus* L., superficially very much like a Swallowtail Butterfly, has been taken at Cape York. Besides these there are a number of much smaller but very elegant, white species, expanding 30-50 mm., belonging to the genera *Micronia*, *Acropteris* and *Aploschema*, of which *Aploschema discata* Warr. (pl. 33, fig. 19), delicately marked with numerous transverse grey striae, is a fine example.

Superfamily XII. NOTODONTOIDEA

Maxillary palpi absent. Forewings with areole often present (except in Sphingidae), Cu_2 absent, R_3, R_4 and often R_5 stalked, M_2 arising from or above middle of cell (except in *Antimimistis* and *Microdes*). Hindwings with Cu_2 absent, *Sc* approximated to or connected with cell, or else (Sphingidae) with R_1 strongly developed. Larvae very variable.

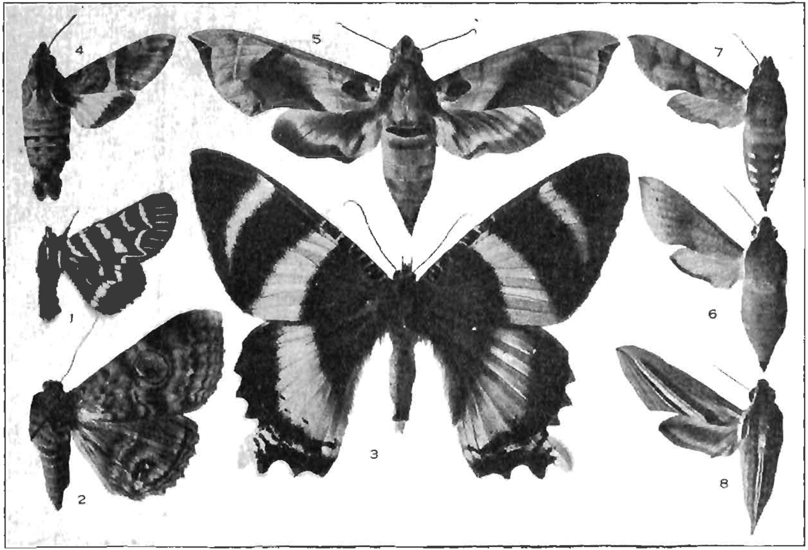
The group contains seven families, of which the first two stand well apart from the other five. These latter are all closely related, and may be called the Section Geometrites; they are characterized by the larvae nearly always having prolegs only on abdominal segment 6 and the anal segment, progressing in a series of loops (hence the name Geometers) and often showing a close protective resemblance to twigs (fig. Z12). The following Key will distinguish the families:—

Plate 36

AUSTRALIAN LEPIDOPTERA (Heterocera)

All figures natural size

1. *Comocrus behri* Angas (Fam. Noctuidae).
2. *Sericea spectans* Guer. (Fam. Noctuidae).
3. *Alcidis zodiaca* Butl. (Fam. Uraniidae).
4. *Macroglossum hirundo errans* Walk. (Fam. Sphingidae).
5. *Deilephila placida* Walk. (Fam. Sphingidae).
6. *Hippotion scrofa* Bd. (Fam. Sphingidae).
7. *Hippotion brennus johanna* Kby. (Fam. Sphingidae).
8. *Therctra oldenlandiae* Fabr. (Fam. Sphingidae).



W. C. Davies photo.

AUSTRALIAN LEPIDOPTERA (HETEROCERA)

1. Hindwings with *Sc* not bent at base. 2
Hindwings with *Sc* strongly bent at base* (Section GEOMETRITES). 3
2. Hindwings with free piece of R_1 absent. *Sc* approximated to and sometimes connected with cell. Fam. 53. NOTODONTIDAE
Hindwings with free piece of R_1 always strongly developed. *Sc* well separated from cell. Fam. 54. SPHINGIDAE
3. Hindwings with M_2 absent (rarely weakly developed). Fam. 56. BOARMIIDAE
Hindwings with M_2 well developed. 4
4. Hindwings with *Sc* diverging from cell near base. Fam. 58. STERRHIDAE
Hindwings with *Sc* approximated to or connected with cell to about middle. 5
5. Hindwings with *Sc* fusing with cell to about middle (rarely connected with cell beyond middle). Fam. 59. LARENTIIDAE
Hindwings with *Sc* not fused with cell.† 6
6. Hindwings with M_2 strongly approximated at base to M_1 Fam. 57. GEOMETRIDAE
Hindwings with M_2 not approximated to M_1.‡ Fam. 55. OENOCHROMATIDAE

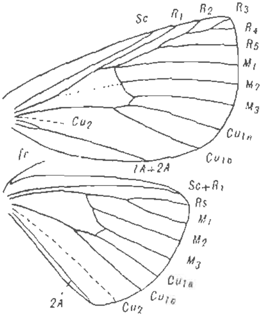


FIG. 245. Wing-venation of *Epicoma tristis* Lew., Australia. Fam. Notodontidae, subfam. Cnethocampinae. Lettering as in fig. A8, p. 22 [*A. Philpott del.*

Family 53. **Notodontidae** [Aus. 67, N.Z. 0]. Forewings with areole often present. Hindwings with M_2 rather weakly developed, from middle of cell, rarely absent; *Sc* approximated to and sometimes connected with cell at one-fourth or middle, usually approximated until towards the end of cell.

A fairly large family, naturally divisible into two subfamilies. The Notodontinae, with haustellum usually present, abdomen without anal tuft, and antennae of female usually simple, are the larger group, containing 44 Australian species belonging to many genera. *Hylcora* and *Danima* are endemic genera containing large insects found in the temperate parts of the continent. *Hylcora dilucida* Feld. expands 45-90 mm., its rich brown forewings with strongly angulated markings. *Danima banksiae* Lew. (pl. 39, fig. 2), expanding up to 3 inches, has the abdomen mostly yellow, the thorax and dull brownish forewings heavily clothed with whitish scales; its larva feeds on *Banksia* and *Hakea*. *Neola semiaurata* Walk., expanding 45-60 mm., has black forewings with a speckling of whitish scales, and hindwings orange with broad, fuscous termen. *Cerura*, *Hoplitis* and *Stauropus* are genera which extend from Europe into the northern parts of Australia. *H.*

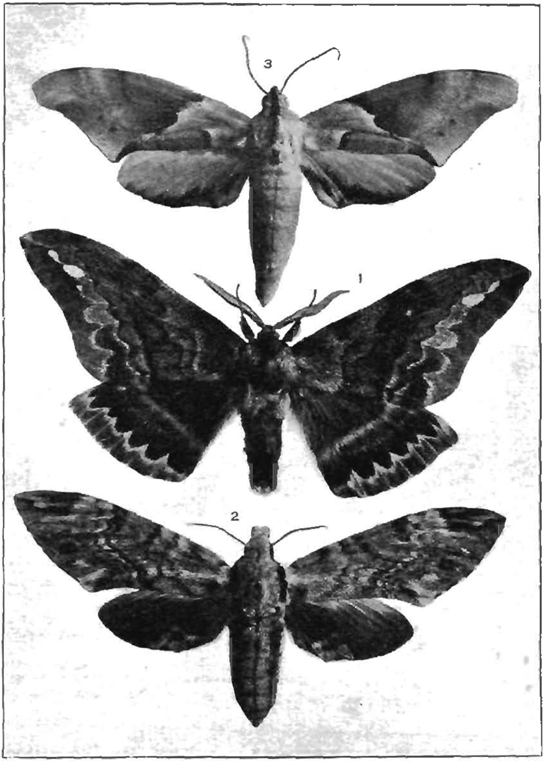
*Except in *Dieeratucha* of the Oenochromatidae.
†Except in *Hypographa* and its allies.
‡Except in *Ceruia* and *Sarcinodes*.

PLATE 37

AUSTRALIAN LEPIDOPTERA (HETEROCERA)

All figures natural size

1. *Chelepteryx collesi* Gray (Fam. ANTHELIDAE).
2. *Psilogramma menephron casuarinae* Walk. (Fam. SPHINGIDAE)
3 *Coequosa australasiae* Don. (Fam. SPHINGIDAE), small male.



W. C. Davies photo.

AUSTRALIAN LEPIDOPTERA (HETEROCERA)

cydista Turn. (pl. 35, fig. 7) is a handsome buff and grey species with whitish hindwings. *C. australis* Sc. and *C. multipunctata* B. B. are the Australian Puss Moths; they have forewings white with numerous black spots, hindwings white in male, fuscous in female, and expand 40-70 mm.; their larvae resemble that of the European Puss Moth. *Rosama indistincta* Roth. is the only species having

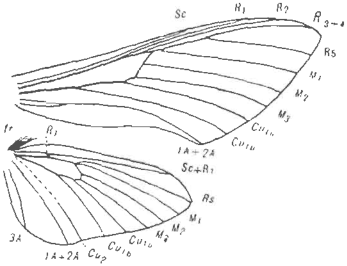


FIG. Z46. Wing-venation of *Hippotion celerio* L., Australia and New Zealand. *Fam. Sphingidae.* Lettering as in fig. A8, p. 22. [*A. Philpott del.*

the prominence on dorsum of forewings from which the name of "Prominents", given to this family, is derived.

The Cnethocampinae are a much smaller group having the haustellum absent, the abdomen ending in an anal tuft, and the antennae of the female usually bipectinate. They are well represented in Australia by 24 species, of which 14 belong to the endemic genus *Epicoma*. *E. melanospila* Wall. (pl. 39, fig. 3) is a very common species with silvery-white forewings marked with a dark spot and oblique band. The genus *Ochrogaster* contains the well known Processionary Moth of Australia, *O. contraria* Walk. expanding 40-60 mm., a common species of a brownish colour, with a white spot on each forewing. Its larvae are very hairy, and live in large communities in silken bag-shelters in trees; they wander in search of food in long processions in single file, and may sometimes be met with crossing a road.

Family 54. **Sphingidae** (Hawk Moths) [Aus. 55, N.Z. 2]. Haustellum usually very strongly developed; antennae thickened, slenderly fusiform, usually with hooked tip, and ciliated in male; thorax and abdomen stout. Forewings without areole, R_3 and R_4 nearly always coincident. Hindwings with Sc well separated from cell throughout, R_1 strongly developed, $Sc+R_1$ approximated to Rs beyond cell. Larvae shagreened or finely tuberculate, without hairs, generally tapering from behind forwards and with an anal horn. Pupae naked, underground or hidden in débris.

This great family, easily recognized by the long, narrow forewings, short hindwings, muscular thorax and stout, fusiform body, (all characters correlated with powerful flight), is only moderately well represented in Australia. No endemic species occur in New Zealand, the only recorded ones being the very widespread *Sphinx convolvuli* L. and *Hippotion celerio* L. Both of these and the common *Deilephila livornica* Fab. occur throughout Australia also. Of endemic

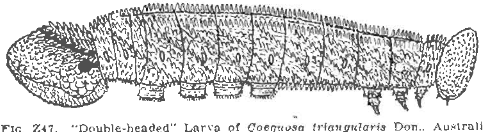


FIG. Z47. "Double-headed" Larva of *Coequosa triangularis* Don., Australia. Fam. Sphingidae. Length 4 inches. [*R. J. T. del.*

genera, the primitive *Hopliocnema* has two species, pale grey in colour, somewhat resembling Notodontids; they are only found in the arid interior, the larvae feeding on She-oak (*Casuarina*). *Cocnotes eremophilae* Luc. is another desert species, grey in colour, expanding 55 mm., whose larvae feeds on *Eremophila*. *Psilogramma menephron casuarinae* Walk. (pl. 37, fig. 2) is the common, large, grey Casuarina Hawk-moth. *Sphinx godarti* W. S. M. is a desert species very similar to the Convolvulus Hawk-Moth, but paler and without any pink on abdomen. *Cizara* is an interesting, endemic genus containing only one species, *C. ardenia* Lew. (pl. 27, fig. 32), of graceful shape and peculiar coloration. Twc of the largest Hawk Moths known belong to the endemic genus *Cocquosa*: *C australasiae* Don. (pl. 37, fig. 3) expands up to 6 inches; it has pale brown or fawn-coloured forewings, yellowish hindwings merging to brown on termen. The immense *C. triangularis* Don. (pl. 34), specimens of which have been taken expanding 8 inches, is much darker, the forewings brown with a large dark triangular mark, the hindwings orange basally, shading to dark brown. The huge caterpillars (fig. Z47), which feed upon Proteaceae and Eucalypts, have enormous anal claspers and a large eye-spot on either side above them, and taper markedly to the small head. The posterior end deceptively resembles a large head and the larva is known as the "double-headed caterpillar."

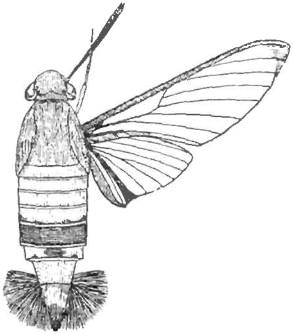


FIG. Z48. *Cephonodes hylas* L., Australia. Fam. Sphingidae. Length of body 41 mm. [*R. J. T. del*

The Humming-bird Hawks of the genus *Macroglossum* are well represented in Queensland by a number of very similar species having dark forewings and orange hindwings with dark termen, of which *M. hirundo errans* Walk. (pl. 36, fig. 4) is one of the commonest. *M. micacea* Walk. has black hindwings with whitish costa; *M. tenebrosum* Luc. (=*M. nox* Butl.) has deep bluish-black hindwings. The allied Bee-hawks of the genus *Cephonodes* are represented by three species, but only *C. hylas* L. (fig. Z48) is at all common. This species flies by day in hot sunshine at Lantana and other flowers, and is a beautiful sight with its fine, bushy "tail" spread out.

Of Oriental and more widespread genera a considerable Hawk Moth fauna has entered Australia from the North and spread southward along the Eastern coastline, some of the species reaching to Sydney and beyond. *Chromis erotu*. Cram. is a large, brownish species with rich orange hindwings, whose larva feed on wild vines (*Vitis*). *Deilephila placida* Walk. (pl. 36, fig. 5) and the allied *D. gloriosa* Roth. are large species with beautifully marbled, brown forewings *Acosmeryx anceus* Stoll is about as large, but with dull brown wings, almos unicolorous. *Nephele subvaria* Walk. is somewhat similar, but has grey forewings, often with a white lunule, hindwings brown. Several species of *Hippotion* occur, all rather small in size; *H. scrofa* Bd. (pl. 36, fig. 6), with dull, brownish grey forewings and orange-brown hindwings, is a very common species whos

larva feeds on Sweet Potato (*Ipomaea*), and sometimes does considerable damage. *H. brennus johanna* Kby. (pl. 36, fig. 7) is a rarer tropical species with rich red-brown body and wings, and two rows of silver spots on abdomen. *Panacra splendens* Roth. is a rare and beautiful North Queensland species with excavated termen to forewing. The large genus *Theretra* is well represented in Queensland by medium to rather large species with narrow, pointed forewings. A group of rather large forms, with olive-grey or greenish forewings, includes *T. queenslandi* Luc., with an oblique band on forewings, *T. clotho* Dr., *T. inornata* Walk. and *T. tryoni* Misk. *T. nessus* Dr., extending from India to Queensland, is a large and handsome species with a pair of longitudinal golden bands along abdomen. Of smaller species, we may mention the prettily marked, allied species *T. latreilli* W.S.M., *T. oldenlandiae* Fabr. (pl. 36, fig. 8) and the very handsome *T. turneri* Luc.

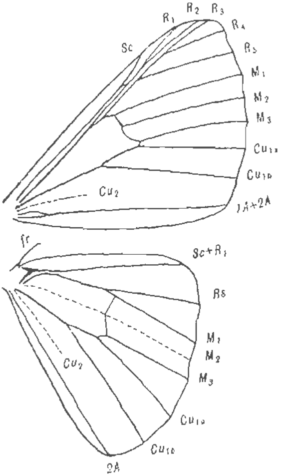


FIG. 249. Wing-venation of *Boarmia* (*Cleora*) *canescaria* Gn., New Zealand. Fam. Boarmiidae. Lettering as in fig. A8, p. 22, except *fr.* frenulum. [*A. Philpott del.*

Section GEOMETRITES

Family 55. **Oenochromatidae (Monocteniidae)** [Aus. 174, N.Z. 11] Forewings with areole usually present, R_1 often fusing with areole, much less often with *Sc*. Hindwings with *Sc* closely approximated to cell from near base to beyond middle (fusing with cell in *Hypographa* group), or, if not, then connected with cell near base; M_2 well developed from about middle of cell (in *Cernia* from well above middle, in *Sarcinodes* from upper angle).

This family contains a number of primitive offshoots from the original Geometrite stem; though numerous in Australia, it is comparatively poorly represented in other parts of the world. *Taxeotis* and *Nearcha* are large Australian genera containing closely similar species, all of which fly low and have a habit of settling on the ground: *N. curtaria* Gn. (pl. 39, fig. 4) is a common pale grey species. *Dichromodes* is a very large, allied genus with unipectinate anetnnae in male; it has many Australian species and six in New Zealand. *D. confluaria* Gn. (pl. 39, fig. 5) has black forewings carrying irregularly confluent silvery mark-

ings: it occurs in marshy places. Some of the smaller mountain forms are quite black, such as *D. nigra* Butl. from New Zealand. *Epidesmia* is an Australian genus of moderate size, containing several very common species, of which the

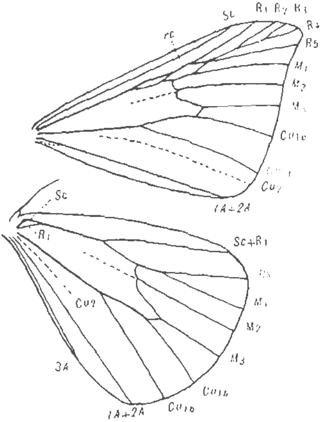


FIG. 250. Wing-venation of *Euphyia deltoidata* Walk., New Zealand. Fam. Larentiidae. Lettering as in fig. A8, p. 22. [A. *Philpott del.*

brown *E. hypenaria* Gn. (pl. 39, fig. 6) is the best known; *E. replicatoria* Walk. (pl. 33, fig. 20) is a handsome, black and white species of strong flight, fond of sitting on tree-trunks with its wings raised; *E. tricolor* Wwd. is an exceptionally large and handsome species, but very rare. The Western Australian *Carthaea saturnioides* Walk. is an extraordinary species, by far the finest in the family; it superficially resembles a Saturnid. *Samana* and *Theoxena* are endemic New Zealand genera; *S. acutata* Butl. (pl. 38, fig. 14) is one of the two known species of the former genus, both rare. *Epirrhanthis alectoraria* Walk. is a brown species with very variable markings, whose larva is often a pest on *Pittosporum* hedges in New Zealand. The genus *Oenochroma* and allies include some beautifully coloured Australian species, of which the rich rosy-purplish *Oe. vinaria* Gn. (pl. 39, fig. 7) is a good example. *Gastrophora henricaria* Gn. (pl. 35, fig. 8) is a large and conspicuous species with orange-yellow hindwings.

Family 56. **Boarmiidae (Selidosematidae)** [Aus. 292, N.Z. 44]. Forewing with areole very seldom present, males often with a basal fovea, R_3, R_4 and R_5 stalked, R_1 and R_2 separate or stalked, often fusing with *Sc* and R_3. Hindwings with *Sc* approximated to cell, usually to about middle, *Rs* and M_1 nearly always arising separately, M_2 absent, or rarely weakly developed. Larvae mostly complete loopers, protectively resembling twigs.

This large and widely distributed family is well represented in both countries. The huge genus *Boarmia** (*Selidosema*) is represented by numerous species in both countries, all fairly large moths with a more or less intricate and variable pattern: the Australian *B. luxaria* Gn. (pl. 39, fig. 8), the New Zealand species *B. pungata* Feld. (pl. 31, fig. 22), *B. productata* Walk., *B. pelurgata* Walk., *B. dejectaria* Walk. (pl. 31, fig. 23) and *B. rudiata* Walk., well illustrate the types of pattern in this genus. The speckled *Ectropis camelaria* Gn. (pl. 39, fig. 9) is a conspicuous Eastern Australian species. *Idiodes apicata* Gn. (pl. 39, fig. 10) is a very common Australian species, brown in colour, often with a pale line running

*Dr. A. J. Turner divides this genus into *Boarmia* (s. str.) and *Cleora* (= *Alcis*) on the condition of R_1 and R_2 in forewing; the N.Z. species would then go into *Cleora*.

from apex of forewing to middle of dorsum of hindwing. *Azelina* is a large South American genus with four handsome species in New Zealand. *A. fortinata* Gn (pl. 38, fig. 15) and *A. gallaria* Walk. are the finest of these. *Drepanodes* is another South American genus, with falcate forewings; there is a single species. *D. muriferata* Walk. (pl. 31, fig. 24) in New Zealand. *Hybernia* is a small genus, found in both countries, with a semi-apterous female. The fine genus *Declana*, peculiar to New Zealand, contains a number of rather stoutly built species, of which the beautiful, black and white *D. atronivea* Walk (pl. 33, fig. 22) from the North Island, and its South Island representative *D. egregia* Feld. (pl. 33, fig. 23) are the most striking; the larvae have prolegs on abdominal segments 5-6, and are protectively coloured, feeding on the Five-finger (*Nothopanax*). *D. glacialis* Huds. (pl. 38, fig. 16) is a very rare and handsome species of very different coloration. A large number of the Australian genera contain protectively coloured species, but the members of the genera *Abraxas, Prasos, Epidesma, Lychnographa, Thalaina, Ctimene, Aplochlora* and others are either conspicuously or brilliantly coloured; from these we have selected for illustration *Thalaina clara* Walk. (pl. 33, fig. 21), *Ctimene synestia* Meyr. (pl. 27, fig. 33) and *Aplochlora vivilaca* Walk. (pl. 27, fig. 34).

Family 57. **Geometridae** (Emeralds) [Aus. 137, N.Z. 0]. Forewings without areole; R_3, R_4 and R_5 stalked from angle of cell, R_2 usually stalked with them, R_1 either free or fusing shortly with *Sc* and R_2. Hindwings with *Sc* approximated to cell near base, diverging at or before middle, rarely approximated to cell beyond middle; M_2 very close to M_1 at origin; frenulum and retinaculum either strongly developed, weak or absent.

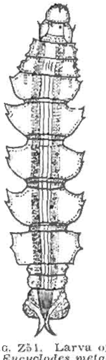


FIG. Z51. Larva of *Eucyclodes metaspila* Walk., Australia. Fam. Geometridae. Note the resemblance to the pinnule of a fern-frond. (After Zeck).

This fine family is well represented in Australia, but is entirely absent from New Zealand and all oceanic islands. The great majority of the species are green in colour, and fly very swiftly when disturbed. Australia possesses some primitive genera with mottled or shaded species resembling Boarmiidae; a good example of these is *Crypsiphona occultaria* Don. (pl. 39, fig. 11). The tropical genus *Dysphania*, of which one species occurs in Northern Australia, is exceptional in its large size and gaudy, purple and orange coloration. Of the green forms, the genera *Euloxia* and *Chlorocoma* contain a number of very pretty species marked or edged with white or pink; *E. meandraria* Gn. (pl. 27, fig. 35) and *Ch. cadmaria* Gn. (pl. 27, fig. 36) are typical of these. *E. gratiosata* Gn. (pl. 39, fig. 12) is an alpine species peculiar in having rich orange hindwings. *Agathia lactata* Walk. (pl. 27, fig. 37) is a very handsomely marked species. Sexual dimorphism is strongly marked in the strikingly delicate and beautiful *Eucyclodes pieroides* Walk. (pl. 33, fig. 24 male, and pl. 39, fig. 13, female) in which the male has semi-transparent wings of gauzy white and pale green, while the female has a very different pattern of rich pale brown and semi-transparent green.* The larvae of *Euloxia* and *Eucyclodes* protectively resemble the pinnules of fern-fronds, having a number of segments expanded laterally (fig. Z51), and resting in a more or less curled position.

Family 58. **Sterrhidae** (Wave Moths) [Aus. 112, N.Z. 1] Forewings with areole usually present, R_1 often fusing with it, never with *Sc*; when areole is absent, all the radial veins are stalked. Hindwings with *Sc* fusing with cell near base, then rapidly diverging. Hind tibiae of male often without spurs and more or less abbreviated or distorted.

This family is well represented in Australia, but, like the preceding one, has no endemic species in New Zealand or oceanic islands. Most of the species are small, white, pale grey or pale brown in colour, with delicate, wavy markings on the wings, and require very careful discrimination. *Leptomeris rubraria* Dbd. (pl. 39, fig. 14) is the commonest species, usually pale brownish, sometimes grey; it is also very common in New Zealand, where it is the only known species of the family. *Chrysocraspeda aurimargo* Warr. (pl. 39, fig. 15) is a handsome North Queensland species with rose-red wings margined with pale orange. *Trygodes* contains species ornamented with green blotches, while those of the genus *Gnamp-*

*It was found impossible to photograph both sexes of this moth on one plate, the male requiring a black background to show up its delicate colouring.—R. J. T.

toloma vary from pinkish grey to green. *Problepsis sancta* Meyr. (pl. 33, fig. 25) is white with a dark blotch on forewings. The genus *Anisodes* and allies form a very distinct natural section of the family.

Family 59. **Larentiidae (Hydriomenidae)** (Carpet Moths) [Aus. 201, N.Z. 181]. Forewings with areole nearly always present, R_1 often fusing or coinciding with it at base, rarely running into *Sc*. Hindwings with discocellulars often bent and M_2 arising from below bend; if straight, M_1 arises from or slightly above middle; *Sc* fusing with cell from near base to about middle, or rarely separate and connected with cell beyond middle. *Antimimistis* and *Microdes* are exceptional genera, as they have M_2 arising close to M_3 in forewings. In some species a peculiar abnormality occasionally occurs, the outer wall of the areole failing to develop.

A large family, principally developed in temperate regions. *Asthena* and allies are superficially very similar to the Sterrhidae. The small brown, grey and whitish species of the genus *Chloroclystis* (called Pug-moths) are especially characteristic of New Zealand, but are also numerous in Australia. *Ch. fumipalpata* Feld. (=*maculata* Huds.) (pl. 31, fig. 25) is the most strikingly marked New Zealand species. *Ch. laticostata* Walk. is an Australian species in which the male has a projecting tuft on costa of forewing; it is not uncommon in parts of New Zealand. *Dasyuris* is a mountain genus with headquarters in New Zealand, but also found in Eastern Australia; *D. callicrena* Meyr. (pl. 38, fig. 17) and *D. partheniata* Gn. (pl. 31, fig. 26) are handsome New Zealand species, *D. hedylepta* Turn. (pl. 39, fig. 24) a well-marked, brown species from the Australian Alps. *Notoreas* contains a large number of species in New Zealand, nearly all mountain forms, the forewings being brown or grey, the hindwings mostly brightly coloured. *N. brephosata* Walk. (pl. 38, fig. 18) is the commonest species; other fine examples of the genus are *N. niphocrena* Meyr. (pl. 38, fig. 19) and *N. synclinalis* Huds. (pl. 38, fig. 20). The allied genus *Euphyia* (*Hydriomena*) is well represented on the mountains of South-Eastern Australia and Tasmania, and also in New Zealand. Of the Australian species, the lovely orange and black *E. chrysocyma* Meyr. (pl. 39, fig. 16), *E. polycarpa* Meyr. (pl. 39, fig. 17), *E. oxygona* Meyr. (pl. 39, fig. 18), *E. stereozona* Meyr. (pl. 39, fig. 19), with orange and dark brown hindwings and paler yellow bands on forewings, and the handsome *E. perornata* Walk. (pl. 27, fig. 38) are some of the most striking forms. *Euphyia purpurifera* Fered. (pl. 31, fig. 27) is a New Zealand species with rich green forewings crossed by a broad, angulated, purplish band. *Larentia* and *Xanthorhoë* are large genera with similar distribution to *Euphyia*, but exceptionally well represented in New Zealand. The finest New Zealand species are *X. cataphracta* Meyr. (pl. 38, fig. 21), *X. helias* Meyr. (pl. 38, fig. 22), *X. adonis* Huds. (pl. 38, fig. 24) and *L. chlamydota* Meyr. (pl. 38, fig. 23). *L. pseudostenaria* Huds (pl. 33, fig. 27) is pale buff in colour. *L. oraria* Philp. is abundant in low-lying coastal areas, but only males have been found; the female is probably apterous. *L. clarata* Walk. (pl. 31, fig. 28) is a fine mountain species found in the South Island. *L. chlorias* Meyr. is a rarer and smaller species, bright yellow with rich brown markings. The genus *Venusia* includes the well-known Native Flax Moth of New Zealand, *V. praefectata* Walk. (pl. 33, fig. 26), a pale coloured species, whose larva is a pest on Native Flax (*Phormium tenax*), attacking the undersides of the leaves and exposing the fibres, causing them to decay, and also the handsomely marked *V. verriculata* Feld. (pl. 31, fig. 29), whose larva feeds on the native Cabbage Tree (*Cordyline*) and frequently much disfigures the leaves. The handsome *V. xanthospis* Meyr. (pl. 38, fig. 25) is a smaller species of very different appearance. From numerous Australian forms typical of the family we have selected for figuring *Larentia epicrossa* Meyr. (pl. 39, fig. 20), *Xanthorhoë heliacaria* Gn. (pl. 39, fig. 21), *Chaetolopha leucophragma* Meyr. (pl. 39, fig. 22), *Melitulias discophora* Meyr. (pl. 39, fig. 23), *Diploctena argocyma* Turn. (pl. 39, fig. 25) and *D. nephodes* Meyr. (pl. 39, fig. 26). Of the more aberrant genera, *Microdes* is found in both countries, *Antimimistis* in Australia only, *Asaphodes* in New Zealand only. The endemic New Zealand genus *Elvia*, containing only the pretty, green species *E. glaucata* Walk. (pl. 38, fig. 26) is peculiar in folding its wings longitudinally in repose. The two most highly specialized genera are the Oriental and Australian *Sauris* and the allied New Zealand *Tatosoma*, both of which have the hindwings greatly reduced in size and carrying a pocket or pouch near the termen in the males; in addition, *Tatosoma* has the abdomen in the male greatly elongated. *S. hirudinata* Gn. (pl. 39, fig. 27) extends from Port Macquarie northwards; the genus *Sauris* itself ranges as far as Ceylon. Of the species of *Tatosoma*, the finest are *T. lestevata* Walk. (pl. 38, fig. 27) and *T. tipulata* Walk. (pl. 31, fig. 30), both having rich green forewings with a darker, wavy pattern.

Superfamily XIII. BOMBYCOIDEA

Forewings with cell small, areole absent (probably in pupal wing also) branches of Rs stalked, M_2 arising from or above middle of cell, or stalked with M_1. Hindwings with *Sc* diverging from cell at base, M_2 arising from or above middle or at upper angle of cell. In this group the family Eupterotidae is merged with the Bombycidae, there being no valid reason for keeping them separate. This leaves only two families found in Australia (both absent from New Zealand): they can be distinguished as follows:—

Hindwings with two anal veins.	Fam. 60. BOMBYCIDAE
Hindwings with only one anal vein.	Fam. 61. SATURNIIDAE

Family 60. **Bombycidae** [Aus. 7. N.Z. 0]. Haustellum absent: labial palpi moderate, short or absent: antennae bipectinate to apex in both sexes; tibial spurs short. Forewings with Cu_2 usually absent, sometimes present. Hindwings with frenulum present or absent, Cu_2 usually absent (present in *Gastridiota*), R_1 present near base, or absent. Larvae either smooth or verrucose. Pupae in a cocoon of fine silk.

All but one of the Australian species are confined to Queensland. *Panacela lewinae* Lew. (pl. 30, fig. 25) is a rather small, brownish moth with a dark brown fascia across forewings: it is widely distributed in Eastern Australia. The larvae are very hairy and provided with stiff, short pencils of hairs arising from warts (verrucae) on each segment: they are gregarious, constructing bag-like shelters of silk on Eucalypts, *Tristania*, *Exocarpus* and other trees. The sexes are very different in appearance. Other genera represented are *Gastridiota*, *Mallodeta*, *Eupterote* and *Cotana*; the species of the last-named genus have a weak frenulum. *Eupterote expansa* Luc. is a very large moth, expanding up to 5 inches or more, without a frenulum. The Silk-worm Moth (*Bombyx mori* L.) is reared domestically on mulberry or lettuce in both countries: though introduced from Europe, its original home was China.

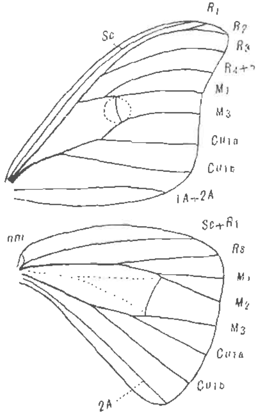


FIG. Z52. Wing-venation of *Antheraea eucalypti* Sc., Australia. Fam. Saturniidae. Lettering as in fig. A8, p. 22. [*R. J. T. del.*

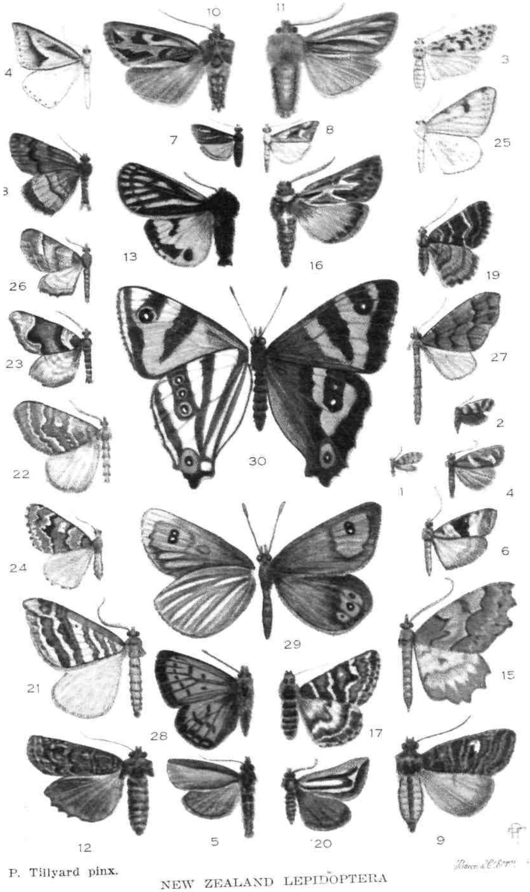
Family 61. **Saturniidae** (Emperor Moths) [Aus. 9, N.Z. 0]. Haustellum absent (rarely weakly developed): labial palpi short or absent; antennae very short, bipectinate to apex in both sexes, with two pairs of pectinations on each segment; *hind tibiae without middle spurs; all spurs short or absent. Forewings*

PLATE 38

NEW ZEALAND LEPIDOPTERA

All figures natural size

1. *Sabatinca aurella* Huds. (Fam. MICROPTERYGIDAE).
2. *Borkhausenia chrysogramma* Meyr. (Fam. OECOPHORIDAE).
3. *Izatha peroncanella* Walk. (Fam. OECOPHORIDAE).
4. *Harmologa sanguinea* Philp. (Fam. TORTRICIDAE).
5. *Gelophula siraca* Meyr. (Fam. TORTRICIDAE).
6. *Scoparia aspidota* Meyr. (Fam. PYRAUSTIDAE).
7. *Crambus heliotes* Meyr. (Fam. CRAMBIDAE).
8. *Diptychophora interrupta* Feld. (Fam. CRAMBIDAE)
9. *Melanchra meyricki* Hamps. (Fam. NOCTUIDAE).
10. *Melanchra maya* Huds. (Fam. NOCTUIDAE).
11. *Ichneutica ceraunias* Meyr. (Fam. NOCTUIDAE).
12. *Erana graminosa* Walk. (Fam. NOCTUIDAE).
13. *Metacrias erichrysa* Meyr. (Fam. ARCTIIDAE).
14. *Samana acutata* Butl. (Fam. OENOCHROMATIDAE).
15. *Azelina fortinata* Gn. (Fam. BOARMIIDAE).
16. *Declana glacialis* Huds. (Fam. BOARMIIDAE).
17. *Dasyuris callicrena* Meyr. (Fam. LARENTIIDAE).
18. *Notoreas brephosata* Walk. (Fam. LARENTIIDAE).
19. *Notoreas niphocrena* Meyr. (Fam. LARENTIIDAE).
20. *Notoreas synclinalis* Huds. (Fam. LARENTIIDAE).
21. *Xanthorhoë cataphracta* Meyr. (Fam. LARENTIIDAE)
22. *Xanthorhoë helias* Meyr. (Fam. LARENTIIDAE).
23. *Larentia chlamydota* Meyr. (Fam. LARENTIIDAE).
24. *Xanthorhoë adonis* Huds. (Fam. LARENTIIDAE).
25. *Venusia xanthaspis* Meyr. (Fam. LARENTIIDAE).
26. *Elvia glaucata* Walk. (Fam. LARENTIIDAE).
27. *Tatosoma lestevata* Walk. (Fam. LARENTIIDAE).
28. *Chrysophanus sallustius* Fabr. (Fam. LYCAENIDAE).
29. *Argyrophenga antipodum* Dbd. (Fam. NYMPHALIDAE).
30. *Dodonidia helmsi* Fered. (Fam. NYMPHALIDAE).



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NEW ZEALAND LEPIDOPTERA

with Cu_2 absent, *Rs* with only three branches, *M* with two. Hindwings without frenulum and retinaculum. *Rs* arising from before angle of cell. Larvae (fig. Z53) *highly ornamented with coloured spines or setae placed on scoli.*

A widespread family of moderate size, containing moths of very large wing-area and including the largest known species in the whole Order. The seven species of *Antheraea*, or Australian Emperor Moths, are all fine insects with large eye-spots on one or both pairs of wings. *A. eucalypti* Sc. (pl. 35, fig. 9) is the commonest, expanding 4 to 5½ inches, fawn to reddish brown in colour, with pinkish eye-spot on forewings, and larger, orange eye-spot ringed with black on hindwings. The larva (fig. Z52) is a handsome, green caterpillar with scoli carrying retractile red and blue spines; it feeds on Eucalypts and the Pepper Tree

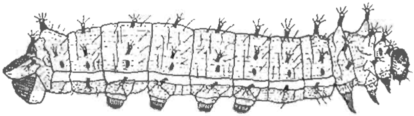


FIG. Z53 Larva of *Antheraea eucalypti* Sc. Length 3 inches. [*R. J. T. del.*

(*Schinus mollis*). The short, stout pupa is enclosed in a broadly oval, hard, brown cocoon of strong silk. *A. loranthi* Luc. and *A. helena* Wh. are larger and browner species found in Queensland. *A. astrophela* Walk. is smaller, often lemon-yellow in colour, with a slender, oblique stripe on forewings. *A. janetta* Wh. is a large and very variable species with very small eye-spots. *A. saccopaea* Turn. and *A. eugaea* Turn. are rare Queensland species of smaller size. The great Atlas Moths, which have central scaleless patches on the wings, are represented by two species. *Attacus edwardsi* Roth. is a huge moth without tails on hindwings, found at Port Darwin and in Timor. *Coscinoscera hercules* Misk. (pl. 1) is a magnificent, dark brown species found in North Queensland and Papua. The female is of immense size, one specimen reared by Mr. F. P. Dodd measuring 10½ inches in expanse and the same distance from apex of forewings to tip of tail on hindwings. The males have narrower wings, the tail being very long and slender. These moths are reared by securing the huge, tough cocoons, which are placed high up in the forks of great trees in the tropical scrub.

Division *RHOPALOCERA*
(Butterflies)

Day-flying species with antennae clubbed or more or less swollen at tips. Forewings in pupa either with tracheae R_{2-3} and R_{4-5} arising far apart on R (R_{4-5} arising close to base) or with a single radial trachea giving off R_1 and R_2 anteriorly, followed by R_3 and R_4 posteriorly; in imago, areole absent through loss of chorda. Hindwings without frenulum (except in male of Euschemon, fig. Z54); *wing-coupling amplexiform. Larvae variable. Pupae with well-developed pilifers* (figs. Z57, Z61, Z66, *pf*).

Whether the Rhopalocera are entitled to more than superfamily rank is open to doubt. The three characters given in the Key on p. 415 would suffice to establish the Division, were it not that each of them occurs also in several otherwise unrelated families of Heterocera, though, as it happens, nowhere else in combination. The formation of an areocel owing to obsolescence of the chorda at metamorphosis is a very important character, but is shared with the Tineoidea, Pterophoroidea and Pyraloidea. The pupae of Rhopalocera, however, differ from those of all Heterocera except some Cossidae in having R_{4-5} arising separately from R_{2-3}, the former arising close to the base in the pupal wing, the latter far distad; this character has been proved by dissection for the Hesperiidae, Papilionidae and Nymphalidae, but appears to be superseded by a more highly specialized condition in the pupae of Pieridae and Lycaenidae (in which, however, newly-formed pupae have not yet been examined). The persistence of the strong basal portion of R_1 and the presence of *hm* in the hindwing of the imago are also important characters, but the former is found in some Cossidae and all Sphingidae, the latter in some of the larger Uraniidae (fig. Z44); it must also be borne in mind that this character is lost in the Lycaenidae and some Pieridae. The presence of a strong cross-vein between Cu_1 and *1A* in the forewing of Papilionidae, and the

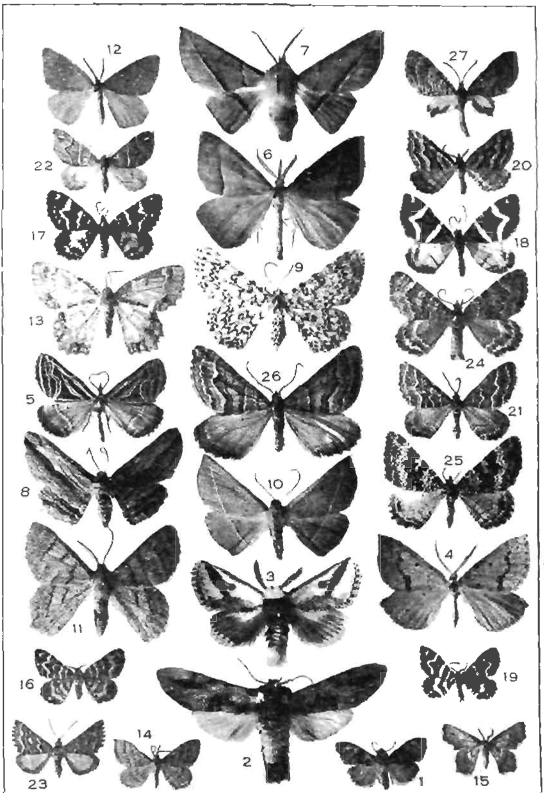
Plate 39

AUSTRALIAN LEPIDOPTERA (Heterocera)

All figures natural size

1. *Roeselia lugens* Walk. (Fam. Nolidae).
2. *Danima banksiae* Lew. (Fam. Notodontidae).
3. *Epicoma melanospila* Wall. (Fam. Notodontidae).
4. *Nearcha curtaria* Gn. (Fam. Oenochromatidae).
5. *Dichromodes confluaria* Gn. (Fam. Oenochromatidae).
6. *Epidesmia hypenaria* Gn. (Fam. Oenochromatidae).
7. *Oenochroma vinaria* Gn. (Fam. Oenochromatidae).
8. *Boarmia luxaria* Gn. (Fam. Boarmiidae).
9. *Ectropis camelaria* Gn. (Fam. Boarmiidae).
10. *Idiodes apicata* Gn. (Fam. Boarmiidae).
11. *Crypsiphona occultaria* Don. (Fam. Geometridae).
12. *Euloxia gratiosata* Gn. (Fam. Geometridae).
13. *Eucyclodes pieroides* Walk. (Fam. Geometridae), female*.
14. *Leptomeris rubraria* Dbd. (Fam. Sterrhidae).
15. *Chrysocraspeda aurimargo* Warr. (Fam. Sterrhidae).
16. *Euphyia chrysocyma* Meyr. (Fam. Larentiidae).
17. *Euphyia polycarpa* Meyr. (Fam. Larentiidae).
18. *Euphyia oxygona* Meyr. (Fam. Larentiidae).
19. *Euphyia stereozona* Meyr. (Fam. Larentiidae).
20. *Larentia epicrossa* Meyr. (Fam. Larentiidae).
21. *Xanthorhoë heliacaria* Gn. (Fam. Larentiidae).
22. *Chaetolopha leucophragma* Meyr. (Fam. Larentiidae).
23. *Melitulias discophora* Meyr. (Fam. Larentiidae).
24. *Dasyuris hedylepta* Turn. (Fam. Larentiidae).
25. *Diploctena argocyma* Turn. (Fam. Larentiidae).
26. *Diploctena nephodes* Meyr. (Fam. Larentiidae).
27. *Sauris hirudinata* Gn. (Fam. Larentiidae).

*Male is figured on Plate 33.



W. C. Davies photo.

AUSTRALIAN LEPIDOPTERA (HETEROCERA)

short anal vein running to dorsum (fig. Z59) are both characters without parallel in the Heterocera: a dissection of the pupa shows the former to be absent during the early part of pupal life, while the latter is seen to be a specialized condition of *2A*. All pupae of Rhopalocera possess well developed *pilifers* (figs. Z57, Z61, Z66, *pf*), a character shared only with the Pterophoroidea and Pyraloidea, and perhaps indicating a common ancestor for these three groups. Though the above evidence may not be sufficient for a final decision, it certainly leaves the choice open, and we shall adopt here the more conservative course of retaining the Rhopalocera as a separate Division.

Though greatly inferior in number of species and variety of form to the Heterocera, the Rhopalocera form a much larger and more important group than might be suspected from the Australian and New Zealand faunas. Their main stronghold is the Tropics, but more especially the Neotropical Region. The great majority of the Australian Butterflies are confined to the Eastern coastline and mountains, and most of these evidently reached Australia by way of Torres Straits. A group of about twenty species of Satyrinae, including *Heteronympha Xenica* and allies, probably reached Australia through Tasmania by a Tertiary Antarctic connection, while a single Skipper, the Western Australian *Exometoeca nycteris* Meyr. seems to be the sole representative of the older Western Australian fauna. The extremely poor Butterfly fauna of New Zealand is chiefly remarkable for its alpine Satyrinae, which fall into two groups; the South Island *Erebia*-group, which has clearly come in through an Antarctic connection, but shows no affinity with the Australian *Xenica*-group; and the genus *Dodonidia*, found in both North and South Islands, which is a close relative of the Australian *Oreixenica*. New Zealand has no Hesperiidae, Papilionidae or Pieridae. The total number of Australian species is 334, of New Zealand species only 16, including occasional immigrants which never breed there.

The Butterflies fall naturally into three great groups, which are here given the rank of Superfamilies, and can be distinguished by the following Key:—

1. Antennae wide apart at bases; forewings with all veins arising separately from cell. XIV. HESPERIOIDEA
   Antennae close together at bases; forewings with R_4 and R_5 stalked. 2
2. Forewings with *2A* running to dorsum; a basal cross-vein present between Cu_1 and *1A*; hindwings with *3A* absent. XV. PAPILIONOIDEA
   Forewings with *2A* looped to *1A*, or absent; no basal cross-vein between Cu_1 and *1A*; hindwings with *3A* present. XVI. NYMPHALOIDEA

Superfamily XIV. HESPERIOIDEA

(Skippers)

Head broad, with bases of antennae widely separate. Hind tibiae usually with middle spurs. Forewings (fig. Z54) with *2A* forming a minute or imperfect fork with *1A*, or absent; all branches of *Rs* arising separately from cell. Hindwing with *Sc* and *R* enclosing a small subcostal cell near base and then fusing together; *hm* present, arising from free part of *Sc*, but not strongly developed, directed basad (sometimes absent); two anal veins present, viz., *2A* and *3A*. Larvae (fig. Z55) naked, more or less cylindrical, with large, strongly chitinized head and constricted neck; feeding more or less concealed. Pupae in a shelter constructed by drawing together the leaves of the food-plant with silk; dehiscing with separation of an apico-ventral head-plate.

There is only one family, the Hesperidae or Skippers; the Neotropical Megathymidae, whose larvae burrow in stems, perhaps deserve family rank, but are absent from Australia.

Family 62. **Hesperiidae** (Skippers) [Aus. 92, N.Z. 0]. Most of the species in this fairly large family can be recognized on the wing by the peculiar habit of resting with the hindwings partially open, but a few rest with wings completely closed, and some with wings expanded. Most of the species have a short, jerky flight, but some fly high and very swiftly. All the Australian species have the antennae more or less hooked at the tip.

The archaic subfamily Euschemoninae contains only the single Australian species *Euschemon rafflesia* W.S.M., known as the Regent Skipper (pl. 40, fig. 1). This lovely insect is remarkable in retaining the frenulum and retinaculum in the male only, a character not found in any other Butterfly. The larvae (fig. Z55) live in shelters made by sewing together two leaves of the Monimiaceous

shrub *Wilkica macrophylla*: the pupa (fig. Z56) lies in the shelter, attached by the cremaster, and also held lightly in position by a stout, silken thread passing

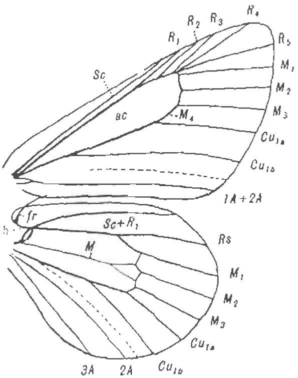


FIG. Z54. Wing-venation of *Euschemon rafflesia* W.S.M., male, Australia. Fam. Hesperiidae, subfam. Euschemoninae. Lettering as in fig. A8, p. 22, except *ac*, areocel; *fr*, frenulum; *h*, humeral veinlet. [*R. J. T. del.*

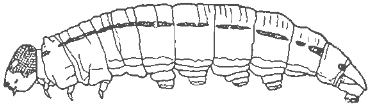


FIG. Z55. Larva of *Euschemon rafflesia* W.S.M. Length 38 mm. [*A. Tonnoir del.*

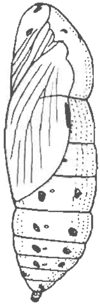
across its middle. The species extends from Port Macquarie to North Queensland.

The Hesperiinae contain few Australian genera. *Exometoeca nycteris* Meyr. is a small, brown skipper of slender bulid, with long, porrect palpi, found in South Western Australia. *Netrocoryne repanda* Feld. (pl. 44, fig. 1) is a much larger, dark brown species with clear whitish areas on the wings; it rests with wings completely expanded. The larvae form shelters of the leaves of *Callicoma serratifolia*. *Chaetocneme* and *Phoenicops* contains much larger, tropical species, similarly coloured.

The Ismeninae are a small group of fairly large, swift-flying forms, which rest with wings completely closed. They are brown to blackish in colour, sometimes with a greenish metallic tinge; the best known species are *Hasora haslia* Swinh. and *Badamia exclamationis* Fabr., both ranging from Northern N.S.W. northwards.

The Erynninae are a large group of tropical and subtropical species whose larvae feed on palms and grasses. Most of the species have a very typical orange-yellow and black coloration. *Cephrenes augiades sperthias* Feld. (pl. 44, fig. 2) is a fine, palm-feeding species found as far south as Sydney. *Telicota augias kreffti* Macl. is not quite so large, with closely similar colouring, and commoner than the previous species. The small, grass-feeding species of the genus *Padraona*

are met with everywhere, the commonest being *P. flavovittata* Latr. (pl. 44, fig. 3), ranging from Port Darwin to Adelaide and Hobart. The dark brown *P. lascivia* Rosen., with rows of 3-4 small pale spots on each wing, is also very common.



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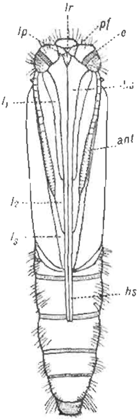

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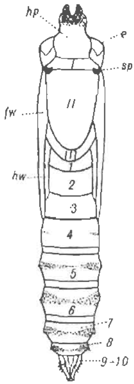

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FIG. Z56. Pupa of *Euschemon rafflesia* W.S.M., lateral view. Length 31 mm. [*A. Tonnoir del.*

FIG. Z57. Pupa of *Cephrenes augiades sperthias* Feld., Australia. Fam. Hesperiidae, subfam. Erynninae. Length 28 mm. Ventral view. *ant*, antenna; *e*, eye; *hs*, haustellum; l_1-l_3, legs; *lp*, labial palpi; *lr*, labrum; *pf*, pilifers. [*R. J. T. del.*

FIG. Z58. Pupa of *Hesperilla picta* Leach, Australia. Fam. Hesperiidae, subfam. Trapezitinae. Length 23 mm. Dorsal view. I, II, III, the three thoracic segments; 1-10, the ten abdominal segments; *e*, eye; *fw*, forewing; *hp*, headpiece, *hw*, hindwing; *sp*, prothoracic spiracle. [*R. J. T. del.*

The Trapezitinae are the dominant group in Australia, and are mostly confined to the more temperate parts. Like the previous subfamily, they have a short, jerky flight and rest with hindwings partly open. Except for a few species in the mountains of Papua, the group is purely an Australian one. About 50 species are known, mostly included in the endemic genera *Signeta*, *Motasingha*, *Hesperilla* and *Anisynta* and in the principally Australian *Toxidia* and *Trapezites*. The larvae feed on a variety of long-leaved plants, such as grasses, chiefly of the genus *Poa*, the Sword-grass (*Gahnia*), the native irises (*Patersonia*) and the Liliaceous genus *Xerotes*. *Hesperilla* contains a number of handsome species with dark brown wings marked with orange or yellow spots, such as *H. idothea* Misk. (pl. 44, fig. 4) and *H. picta* Leach (pl. 44, fig. 5); this latter species and the allied *H. ornata* Leach have the underside of the hindwing ornamented with creamy-white. *Trapezites* contains dark brown species with yellow spots on wings, the finest being the Large Skipper, *T. symmomus* Hub., expanding 45 mm. and found throughout Eastern Australia. Seven species of this group are found in Western Australia and an equal number in Tasmania. *Toxidia* and *Neohesperilla* contain mostly tropical species.

Superfamily XV. PAPILIONOIDEA

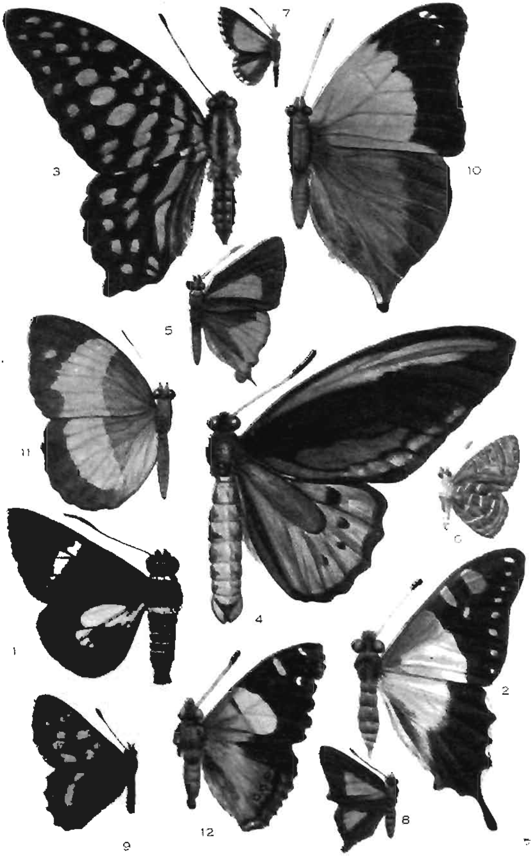
Antennae close together at bases. Hind tibiae without middle spurs. Forewings (fig. Z59) with R_4 and R_5 stalked. Cu_{1a} arising from before middle of cell, a

Plate 40

AUSTRALIAN LEPIDOPTERA (Butterflies)

All figures natural size

1. *Euschemon rafflesia* W.S.M. (Fam. Hesperiidae).
2. *Papilio macleayanus* Leach (Fam. Papilionidae).
3. *Papilio agamemnon ligatus* Roth. (Fam. Papilionidae).
4. *Papilio (Troïdes) priamus euphorion* Gray (Fam. Papilionidae), male.
5. *Deudoryx epijarbas diovis* Hew. (Fam. Lycaenidae), male.
6. *Miletus hecalius* Misk. (Fam. Lycaenidae), male, underside.
7. *Lucia lucana* Fabr. (Fam. Lycaenidae), male.
8. *Paralucia aurifera* Blanch (Fam. Lycaenidae), male.
9. *Oreixenica kershawi ella* Oll. (Fam. Nymphalidae).
10. *Doleschallia bisaltide australis* Feld. (Fam. Nymphalidae).
11. *Cupha prosope prosope* Fabr. (Fam. Nymphalidae).
12. *Pyrameis itea* Fabr. (Fam. Nymphalidae). N.Z. also.



P. Tillyard pinx.

AUSTRALIAN LEPIDOPTERA (BUTTERFLIES)

strong basal cross-vein between Cu_1 and $1A$, the two anal veins strongly diverging, not looped, $2A$ running to dorsum. Hindwings with only one anal vein, viz., $2A$; R_1 strongly developed, forming with Sc a basal subcostal cell; *hm arising from*

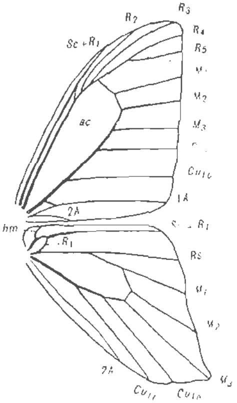


FIG. Z59. Wing-venation of *Papilio sarpedon choredon* Feld., Australia. Fam. Papilionidae. Lettering as in fig. A8, p. 22, except *ac*, areocel. [*R. J. T. del.*

free part of *Sc*, strongly developed, usually directed forwards (basad in *Eurycus*). Larvae (fig. Z60) cylindrical or fusiform, without hairs, but with one or more *pairs of fleshy tubercles; the prothorax has a dorsal slit, out of which there* can be projected a Y-shaped, fleshy process called the *osmeterium*, connected with a scent-gland. Pupae (figs. Z61, Z63) protectively sculptured and coloured, attached head upwards by cremaster and a silken girdle.

Family 63. **Papilionidae** (Swallow-tails) [Aus. 17, N.Z. 0]. This family contains large, swift-flying species expanding from 3 to 7 inches; many of them have tails on the hindwings, but this character is by no means universal. Most of the Australian species are tropical or subtropical; only three of them are peculiar to Australia.

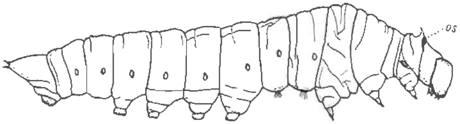
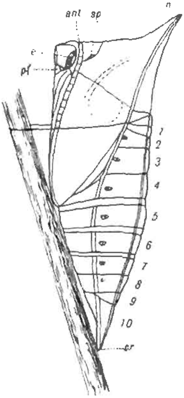


FIG. Z60. Larva of *Papilio sarpedon choredon* Feld. Length 37 mm. *os*, opening of osmeterium. [*R. J. T. del.*

The great and almost world-wide genus *Papilio*, which includes all but one of the Australian species, contains many diverse forms which do not at first sight appear to be congeneric; but all attempts, so far, to divide it into a number of distinct genera have been comparative failures. At present the genera *Troïdes* (*Ornithoptera*) and *Menelaïdes* are merged within it, and three distinct groups are then recognized as follows:—

(1) *The Aristolochia-feeding Papilios*:—Pupa with the head truncate or weakly bifid, the mid-dorsal mesothoracic horn not developed; abdomen

with paired dorsal tubercles on segs. 4-7, prominent or flattened. This section is represented in Australia by two tropical species of the subgenus *Menelaïdes* and by four distinct races of the magnificent *Papilio* (*Troïdes*) *priamus* L. (pl. 40,



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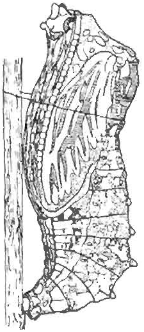

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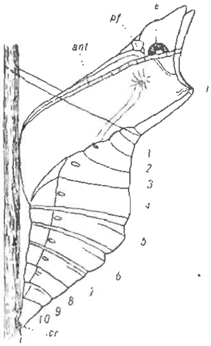

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FIG. Z61. Pupa of *Papilio sarpedon choredon* Feld. Length 28 mm. Lateral view, showing mid-dorsal mesothoracic horn (*h*); *ant*, antennae; *cr*, cremaster; *e*, sculptured eye; *pf*, pilifer; *sp*, thoracic spiracle. Spiracles also visible on abdominal segs. 2-8, that of seg. 8 being small and functionless. [*R. J. T. del.*

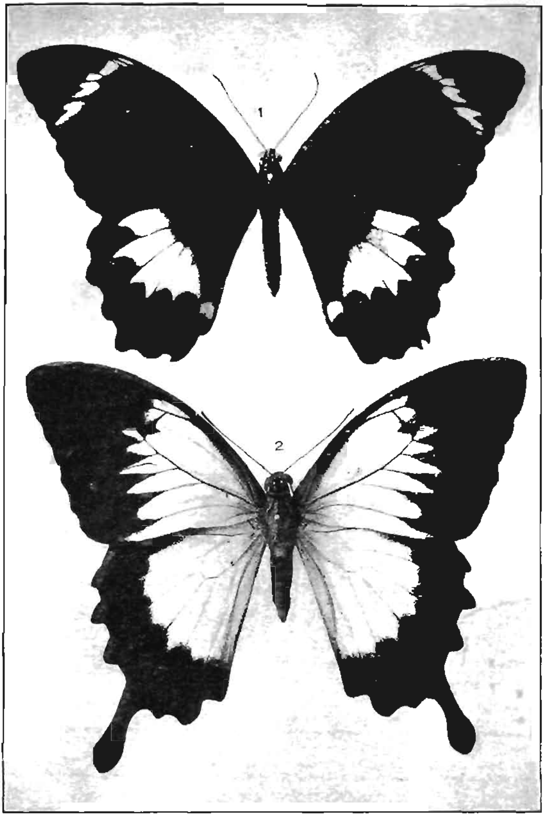
FIG. Z62. Pupa of *Eurycus cressida* Fabr., Australia. Length 27 mm. [*R. J. T. del.*

FIG. Z63. Pupa of *Papilio aegeus* Don., Australia. Length 41 mm. Lateral view, showing bifid head. Lettering as in fig. Z61. [*R. J. T. del.*

fig. 4), one of which (*richmondius* Gray) is found as far south as the Richmond River, N.S.W. The rich black and green males, with golden-yellow abdomen, contrast very strongly with the much larger but duller coloured females, whose black wings are marked with greyish white.

(2) *The Fluted Papilios*:—Pupa (fig. Z63) with the head strongly bifid but the mesothoracic horn not strongly developed. Forewing with *Sc* and R_1 separate. There are seven Australian species, four being tailless and three tailed. Of the former, the commonest are *P. anactus* W.S.M. (pl. 44, fig. 6), peculiar to Australia, and *P. aegeus* Don. (pl. 41, fig. 1); the larvae of both species are sometimes injurious to citrus trees. The prettily marked, tailless *P. demoleus sthenelus* W. S. M., with wings heavily spotted with pale yellow, is peculiar in its habit of resting on the ground and in preferring the dry interior to the moister coastal districts. Of the tailed species, the magnificent *P. ulysses joësa* Butl. (pl. 41, fig. 2) flies high and swiftly in the tropical scrub of North Queensland; it has rich metallic blue wings bordered with black; its larva feeds on *Euodia accedens*. A very distinct species, *P. leosthenes* Dbd., with creamy wings crossed by a number of black bands, the hindwings with long, slender tails, is peculiar to Australia. Superficially it much resembles *P. parmatus* Gray (pl. 44, fig. 7), but the larva, pupa and venation are quite distinct.

(3) *The Kite Papilios*:—Pupa (fig. Z61) with the head not bifid, the mid-dorsal mesothoracic horn very strongly developed. Forewing (fig. Z59) with *Sc* and R_1 fused distally. Of the six Australian species, four are tailless and two tailed. The former consist of a group of closely related species, of which the commonest is *P. sarpedon choredon* Feld. with black wings crossed by a large triangular area of bluish-green; its larva feeds on native Lauraceae and the introduced Camphor Laurel. It is a subspecies of *P. sarpedon* L., which ranges from Ceylon to New Caledonia. The less common but wide-



W. C. Davies photo.

1. *Papilio aegeus* Don. (Fam. PAPILIONIDAE), male.
2. *Papilio ulysses joësa* Butl. (Fam. PAPILIONIDAE), male.

Both figures natural size

spread *P. eurypylus lycaon* Wwd. (pl. 44, fig. 8) has much paler blue-green markings, and spots on the wings. Both these species extend from Cape York to south of Sydney. *P. agamemnon ligathus* Roth. (pl. 40, fig. 3) is a very handsome, green-spotted butterfly found in North Queensland; it is a subspecies of *P. agamemnon* L., which extends from India and China to the Solomons. The tailed *P. aristeus parmatus* Gray (pl. 44, fig. 7) is confined to North Queensland. *P. macleayanus* Leach (pl. 40, fig. 2) is peculiar to Australia, ranging from North Queensland to Tasmania; its larva feeds on Sassafras and Camphor Laurel. A closely related species is found on the mountains of Papua.

The peculiar *Eurycus cressida* Fabr., in which the female has sparsely-scaled, transparent forewings, is common in Queensland and occasionally occurs as far south as Sydney; its larva feeds on *Aristolochia*. During pairing, the large valves (gonocoxites) of the male become detached and remain with the female, forming a *sphragis* or seal affixed to the female copulatory opening. The pupa (fig. Z62) is similar in form to those of the Aristolochia-feeding Papilios (p. 458).

Superfamily XVI. NYMPHALOIDEA

Antennae close together at bases. Hind tibiae without middle spurs. Forewings (figs. Z5, Z64) with R_3, R_4 and R_5 stalked, sometimes R_{3+4} or R_{4+5} a simple vein; anal vein usually simple, the lower half of basal loop (*2A*) seldom present. Hindwings with *Sc* and *R* usually completely fused basally, *hm* present or absent;

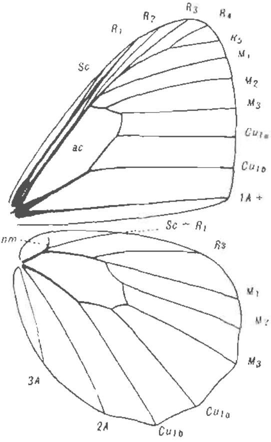


FIG. Z64. Wing-venation of *Tisiphone abeona* Don., Australia. Fam. Nymphalidae, subfam. Satyrinae. Lettering as in fig. A8, p. 22, except *ac*, areocel. [*R. J. T. del.*

two anal veins present, viz. *2A* and *3A*. Larvae (figs. Z65, Z67) and pupae (figs. Z66, Z68) very variable.

Three families are represented in Australia, two of which, the Lycaenidae and Nymphalidae, occur in New Zealand also. They may be separated by the following Key:—

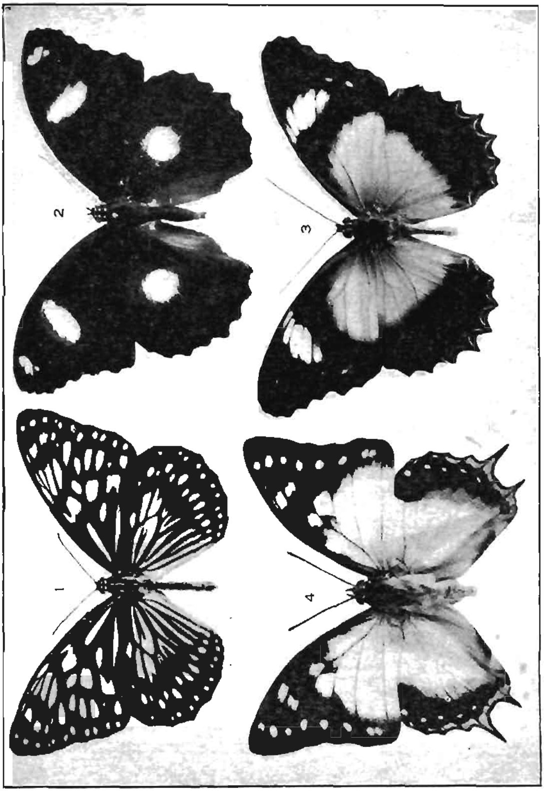
1.	Forelegs perfect in both sexes.	Fam. 65. PIERIDAE
	Forelegs imperfect at least in male.	2
2.	Hindwing with *hm* absent.	Fam. 66. LYCAENIDAE
	Hindwing with *hm* present.	Fam. 64. NYMPHALIDAE

PLATE 42

AUSTRALIAN LEPIDOPTERA (RHOPALOCERA)

All figures natural size

1. *Danaïda melissa hamata* W.S.M. (Fam. NYMPHALIDAE).
2. *Hypolimnas bolina nerina* Fabr. (Fam. NYMPHALIDAE), male.
3. *Cethosia cydippe chrysippe* Fabr. (Fam. NYMPHALIDAE).
4. *Eulepis pyrrhus sempronius* Fabr. (Fam. NYMPHALIDAE).



W. C. Davies photo.

AUSTRALIAN LEPIDOPTERA (RHOPALOCERA)

Family 64. **Nymphalidae** [Aus. 80, N.Z. 11]. Forelegs always imperfect in the male, perfect or imperfect in the female. Hindwing with *hm* always present, subcostal cell rarely present. Larvae (figs. Z65, Z67) very variable, mostly cylindrical; pupae (figs. Z66, Z68) attached by cremaster, nearly always head downwards.

A large family with numerous subfamilies. The Nemeobiinae and Libytheinae are tropical groups with the forelegs perfect in the female; only one species of each is found in Northern Australia. The Elymniinae, which have a small subcostal cell in hindwings, are also represented by a single species in North Queensland. The other subfamilies are fairly large, and all agree in having forelegs imperfect in both sexes and subcostal cell absent.

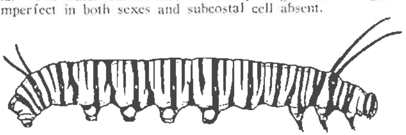


FIG. Z65. Larva of *Danaïda archippus* Fabr., Australia. Fam. Nymphalidae, subfam. Danainae. Length 50 mm. [*R. J. T. del.*

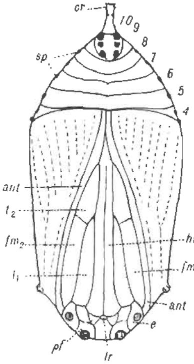


FIG. Z66. Pupa of *Danaïda archippus* Fabr. Length 26 mm. Ventral view. *ant*, antenna; *cr*, cremaster; *e*, eye; fm_2, femur of middle leg; l_1, foreleg; *lr*, labrum; *pf*, pilifer; *sp*, abdominal spiracles; t_2, tibio-tarsus of middle leg; *4-10*, abdominal segments. [*R. J. T. del.*

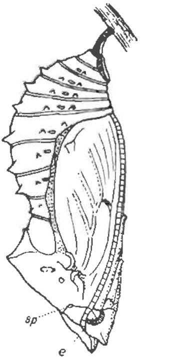


FIG. Z68. Pupa of *Pyrameis gonerilla* Fabr., New Zealand. Fam. Nymphalidae, subfam. Nymphalinae. Length 20 mm. *e*, eye; *sp*, prothoracic spiracle. [*R. J. T. del.*

(Fig. Z67 appears on page 462.)

The Danaïnae (fig. Z5) have *2A* present in forewings forming a small basal fork with *1A*. They are represented in Australia by widespread, tropical species of the genera *Euploea*, *Tellervo* and *Danaïda*. *Euploea* contains large, black or very dark brown, species with white markings; the only one found south of the tropics is *E. corinna* W. S. M. (fig. Z5), which reaches as far as Sydney; its larva feeds on *Mandevillea* and *Ficus*. *Danaïda* contains more brightly coloured species, all widespread. *D. melissa hamata* W.S.M. (pl. 42, fig. 1), black, marked with pale, semi-transparent blue, reaches as far south as Sydney. *D. archippus* Fabr., the Wanderer Butterfly, originally from Central America, is now common from Cape York to Adelaide, and is also occasionally taken in New Zealand. It expands up to 4½ inches, and is a rich red-brown colour with subapical white spots on forewings and the veins marked with black. The larva (fig. Z65) is yellowish

with incomplete rings of black; it feeds on the introduced wild cotton plant, *Asclepias physocarpa* (*Gomphocarpus fruticosus*), and *A. curassiva*. *D. chrysippus petilia* Stoll is a smaller but rather similarly coloured species, without black veinings; it extends all over Australia, and is also a rare immigrant into New Zealand.

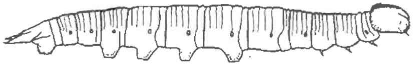


FIG. Z67. Larva of *Tisiphone abeona* Don., Australia. Fam. Nymphalidae, subfam. Satyrinae. Length 37 mm. [*E. J. T. del.*

The peculiar Acraeinae, with sparsely haired palpi and weakly scaled wings, are only represented by the single Australian species *Acraea andromacha* Fabr. (pl. 43, fig. 14), which extends as far south as Sydney.

The Satyrinae (fig. Z64), in which, with the exception of *Melanitis*, the bases of veins *Sc*, *Cu* and *1A+2A* in forewings are conspicuously swollen, are well represented in Australia by more than 30 species, while New Zealand has four. A fine group of endemic genera centred in the mountains of South Eastern Australia includes *Heteronympha*, *Xenica*, *Oreixenica* and allies. *H. merope* Fabr (pl. 43, figs. 1, 2), with races in Tasmania and Western Australia, extends far and wide in Australia; the two sexes are very distinct, the female being particularly beautiful, golden brown and blackish. The rarer *H. mirifica* Butl. (pl. 43, fig. 5) shows even greater sexual dimorphism; the female is black with white markings, and rests on rocks in shady places near streams; the male is of the type of that of *H. merope*, but paler, with fewer markings, and is nearly over when the female begins to emerge. *H. banksi* Leach (pl. 43, fig.4) and the fine mountain species *H. philerope* Bd. (pl. 43, fig. 3) are both golden-brown with dark markings, and show little difference in the sexes. *Xenica acantha* Don. (pl. 43, fig. 6) is a smaller species of similar colouring, but with underside of hindwings beautifully marked in cream and brown, with two eye-spots. *X klugi* Guer. is smaller and less conspicuous. *Oreixenica*, *Nesoxenica* and *Argynnina* form a group of mostly mountain forms, of which *O. lathoniella* Wwd. (pl. 43, fig. 7) with three races, is the most widespread; *O. correae* Oll. is a local alpine species; *O. kershawi* Misk. (pl. 40, fig. 9) and the smaller *O. latialis* W. & L. and *O. orichora* Meyr. are much rarer. *Nesoxenica leprea* Hew. (pl. 43, fig. 8) is a peculiar species confined to Tasmania; the wings are black marked with creamy yellow. *Argynnina tasmanica* Lyell (pl. 43, fig. 9) is a rare species found in Western Tasmania, black with cream and reddish markings.

The fine genus *Tisiphone* is endemic, but probably of tropical origin. There are only two species, *T. helena* Oll. in North Queensland and *T. abeona* Don. ranging from Queensland to Victoria. This latter species has four well-marked races; race *albifascia* Wat. (pl. 43, fig. 11), with orange markings and conspicuous white fasciae on underside of hindwings, occurs in Victoria; race *abeona* Don., similar but darker, with white fasciae much reduced, round Sydney and Blue Mts; race *morrisi* Wat. (pl. 43, fig. 12) with white markings, in Northern N.S.W.; and race *rawnsleyi* Misk., a dull coloured form, on the Blackall Ranges, Queensland. Dr. G. A. Waterhouse has crossed these races and obtained evidence of sex-linked Mendelian colour-characters in the offspring. He has also proved that the race *joanna* Butl. from Port Macquarie is a natural hybrid. The larvae (fig. Z67) of this genus feed on Sword-grass (*Gahnia*), hiding deep down in the sheaths of the leaves.

Of tropical genera, *Hypocysta* contains six small species, three of which extend well down along the Eastern coastline; these are *H. adiante* Hub. and the smaller, duller and closely allied *H. metirius* Butl. and *H. pseudirius* Butl. *H euphemia* Wwd. (pl. 43, fig. 10) is a southern species, not found in Queensland All are dark brown marked with fulvous. *Ypthima arctous* Fabr. has more rounded wings, dark brown with black eye-spot on forewings with two white pupils. *Melanitis leda bankia* Fabr. is a handsome, large, dark brown species with angulated wings; the very variable underside is often protectively coloured to resemble a dead leaf, and the insect flies at dusk.

In New Zealand, the lovely *Dodonidia helmsi* Fered. (pl. 38, fig. 30) flies high and swiftly round trees in native bush in a few localities in both islands its larva feeds on *Uncinia*. This species comes closest to the Australian *Oreixenic*

kershawi (pl. 40, fig. 9) in colouring. The other three species form an alpine group undoubtedly derived from Antarctica, and only found in the South Island. The only common species is *Argyrophenga antipodum* Dbd. (pl. 38, fig. 29), a beautiful and somewhat variable species, whose larva feeds on Tussock Grass (*Poa caespitosa*). *Erebia* (*Percnodaimon*) *merula* Hew. (=*pluto* Fered.) (pl. 31, fig. 31) is a rare alpine species, almost entirely black. *Erebia* (*Erebiola*) *butleri* Fered. (pl. 31, fig. 32) is brownish black with short silvery bars on underside of hindwings, and is the rarest species of all.

The larvae of Satyrinae feed on native grasses and allied plants, and are peculiar in being smooth and in having the end of the abdomen bifid (fig. Z67). Most of the pupae are normal, but some species of *Heteronympha* and *Oreixenica* pupate on the ground.

The Nymphalinae are a large and varied group distinguished by having the discocellulars weakly formed or else the cell open between M_2 and M_3 through loss of *im*. The larvae have spiny or fleshy processes and the pupae are angularly sculptured (fig. Z68). Of tropical and subtropical species one of the commonest is the lovely *Hypolimnas bolina nerina* Fabr. (pl. 42, fig. 2), which is also an occasional immigrant into New Zealand. The male is black, with huge, iridescent blue eye-spots on all four wings; the female is brownish-black with white blotches replacing the eye-spots. *Cethosia cydippe chrysippe* Fabr. (pl. 42, fig. 3) is another fine species, rich red and purplish brown, with a white subapical area on forewings. *Doleschallia bisaltide australis* Feld. (pl. 40, fig. 10), the Queensland Leaf Butterfly, has an underside protectively coloured to resemble a brown leaf with midrib. *Cupha prosope prosope* Fabr. (pl. 40, fig. 11) is a much smaller species of considerable beauty.

The Fritillaries are represented only by a single species, the Australian Fritillary, *Argynnis hyperbius inconstans* Butl. The Admirals and their allies include several common species of *Pyrameis* and *Precis*. *Precis villida* Fabr (pl. 43, fig. 13), the Australian Tortoiseshell, swarms all over the continent, and occasionally occurs in New Zealand. *P. orithyra albicincta* Butl. is a tropical species with blue hindwings. The Australian Painted Lady, *Pyrameis cardui kershawi* McCoy, only differs from the world-wide type-form by the presence of blue-centred eye-spots in hindwings; it also occurs in New Zealand. The Australian Admiral, *P. itea* Fabr. (pl. 40, fig. 12), is very common, and also not uncommon in parts of New Zealand. The New Zealand Red Admiral, *P. gonerilla* Fabr. (pl. 31, fig. 33), is a very common and handsome species resembling the European Red Admiral, but with more red on the wings; its larva feeds on wild nettles (*Urtica ferox* and *U. incisa*).

The Apaturinae or Emperor Butterflies are represented by the Double-tailed Emperor, *Eulepis pyrrhus sempronius* Fabr. (pl. 42, fig. 4), a magnificent cream and black insect ranging from Cape York to Sydney. Its larva and pupa are smooth; the larva feeds on *Acacia* and *Robinia*.

Family 65. **Pieridae** (Whites, Yellows) [Aus. 30, N.Z. 0]. Forelegs fully developed in both sexes. Forewings with R_3, R_4 and R_5 stalked or coincident (fig. Z69), M_1 usually stalked with them, M_2 usually from above middle of cell, anal vein not forked at base. Hindwings with humeral veinlet present or absent; two anal veins present. Larvae cylindrical, smooth or only slightly hairy; pupae protectively sculptured and angulated, usually attached by the cremaster and a silken girdle.

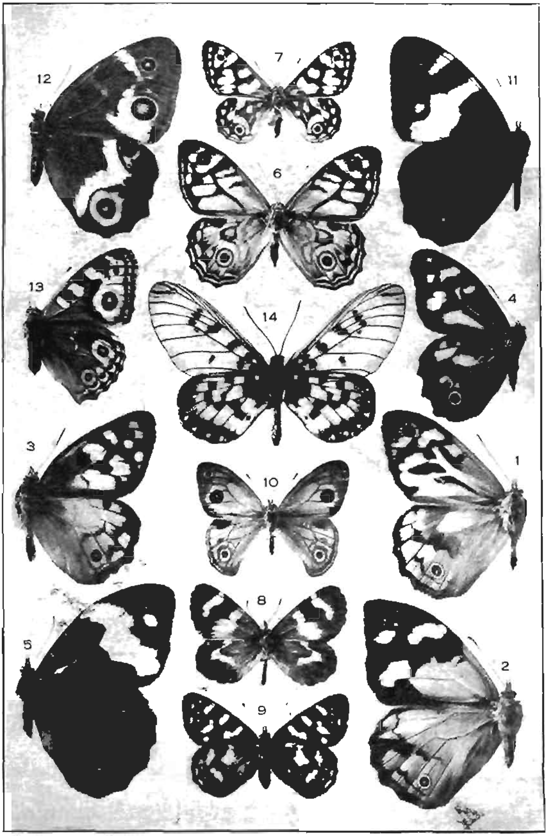
A moderately large family, not represented in New Zealand. All the Australian species belong to genera of tropical origin, and several show strong migratory habits. The most important genus is *Delias* (fig. Z69) with eight species, the larvae of which feed on Native Mistletoe (*Loranthus*) and Native Cherry (*Exocarpus*). The upper side of the wings is white in the males, greyish in the females, with black borders; the undersides are beautifully coloured with black, yellow, orange or red. *D. nigrina* Fabr., common along the Eastern coast, has the wings black beneath, with a yellow subapical patch on forewings, crossed by black veins, and an angulated, narrow, red band on hindwing, broken by black veins. *D. harpalyce* Don. (pl. 44, fig. 9) is a larger species ranging from New South Wales to Victoria and also found in Western Australia; the wings are black beneath, marked with yellow blotches on forewings and red on hind. The larvae spin a web round the leaves of their food-plant, and the pupae are attached thereto. *D. aganippe* Don. (pl. 44, fig. 10) is widely distributed from Southern Queensland southwards and westwards to Western Australia; the wings are black and white beneath, with yellow and red spots. *D. argenthona* Fabr. (pl. 44, fig. 11) has the underside of wings mostly white, but the hindwing has the

Plate 43

AUSTRALIAN LEPIDOPTERA (Rhopalocera)

All figures natural size

1. *Heteronympha merope* Fabr. (Fam. Nymphalidae), male.
2. *Heteronympha merope* Fabr. (Fam. Nymphalidae), female.
3. *Heteronympha philerope* Bd. (Fam. Nymphalidae).
4. *Heteronympha banksi* Leach (Fam. Nymphalidae).
5. *Heteronympha mirifica* Butl. (Fam. Nymphalidae), female.
6. *Xenica acantha* Don. (Fam. Nymphalidae).
7. *Oreixenica lathoniella herceus* W. & L. (Fam. Nymphalidae).
8. *Nesoxenica leprea* Hew. (Fam. Nymphalidae).
9. *Argynnina tasmanica* Lyell (Fam. Nymphalidae).
10. *Hypocysta euphemia* Wwd. (Fam. Nymphalidae).
11. *Tisiphone abeona albifascia* Wat. (Fam. Nymphalidae).
12. *Tisiphone abeona morrisi* Wat. (Fam. Nymphalidae).
13. *Precis villida* Fabr. (Fam. Nymphalidae).
14. *Acraea andromacha* Fabr. (Fam. Nymphalidae).



W. C. Davies photo.

AUSTRALIAN LEPIDOPTERA (RHOPALOCERA)

apical portion black with a series of large red spots; this species extends from Cape York to south of Sydney. *D. mysis* Fabr. (pl. 44, fig. 12), confined to North Queensland, has even more white on underside, the hindwing with a broad,

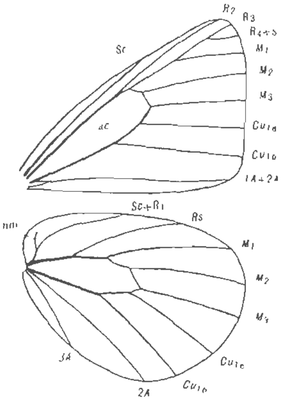


FIG. Z69. Wing-venation of *Delias argenthona* Fabr., Australia. Fam. Pieridae. Lettering as in fig. A8, p. 22. [R. J. T. del.

terminal black band enclosing a narrow scarlet band. These species are amongst the most brilliantly coloured in the whole family. The Travelling Butterfly, *Anaphaeis java teutonia* Fabr., whose larva feeds on the wild caper (*Capparis*) is often abundant in the spring, travelling steadily across hundreds of miles of country, sometimes like a veritable snowstorm. *Huphina* and *Appias* contain white species of similar size (about 2-2½ inches expanse) with more or less black around apex or termen. *Elodina* contains four smaller and more delicate, white species, the best known being *E. egnatia angulipennis* Luc. (pl. 33, fig. 28). *Catopsilia* includes the large Sulphur Butterflies, nearly unicolorous yellow, cream or white, with apex of forewing somewhat more angulated than usual in this family. The species are swift, strong fliers; their larvae feed on *Cassia*. *C. pomona* Fabr. and *C. pyranthe* L. are both common in Queensland, and have numerous races and varieties; a white form of the latter is shown on pl. 33, fig. 29. The most highly specialized genus is *Terias*, containing much smaller species of a bright yellow colour, with *hm* absent in hindwings. The commonest species is *T. smilax* Don., found all over Australia; the larger *T. hecabe sulphurata* Butl. (pl. 44, fig. 13) extends from Cape York to Sydney.

Family 66. **Lycaenidae** (Blues, Coppers, Hairstreaks) [Aus. 115, N.Z. 5]. Fore tarsi of male more or less shortened, or with one or both claws absent. Forewings nearly always with R_{4+5} a simple vein, M_1 nearly always arising separately, M_2 usually from middle of cell, basal fork of anal vein absent. Larvae fusiform or slug-like, with retractile head; often attended by ants, which are attracted by a sweet secretion from the glands of the larva. Pupa usually smooth, not ornamented, variably attached, but usually by cremaster only.

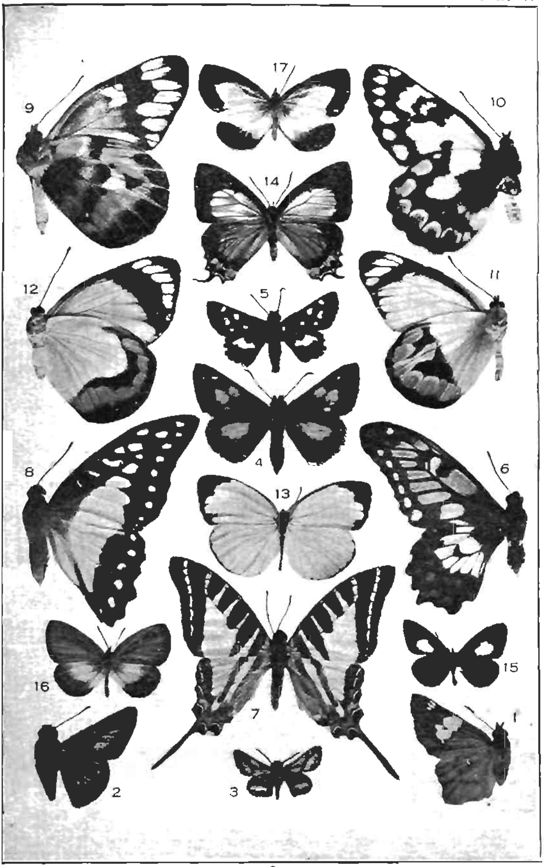
A large family, well represented in Australia but poorly in New Zealand. The archaic Liphyrinae, in which R_4 and R_5 of forewing are separate, are represented only by the extraordinary *Liphyra brassolis* Wwd., found from India to North Queensland. This butterfly expands 70-75 mm. and is quite unlike a typical Lycaenid; its colouring is orange and black, but on emergence it has a covering of white scales on forewings. The remarkable, flattened larva lives in the nests of

Plate 44

AUSTRALIAN LEPIDOPTERA (Rhopalocera)

All figures natural size

1. *Netrocoryne repanda* Feld. (Fam. Hesperiidae).
2. *Cephrenes augiades sperthias* Feld. (Fam. Hesperiidae), male.
3. *Padraona flavovittata* Latr. (Fam. Hesperiidae).
4. *Hesperilla idothea* Misk. (Fam. Hesperiidae), female.
5. *Hesperilla picta* Leach (Fam. Hesperiidae).
6. *Papilio anactus* W.S.M. (Fam. Papilionidae).
7. *Papilio aristeus parmatus* Gray (Fam. Papilionidae).
8. *Papilio eurypylus lycaon* Wwd. (Fam. Papilionidae).
9. *Delias harpalyce* Don. (Fam. Pieridae), underside.
10. *Delias aganippe* Don. (Fam. Pieridae), underside.
11. *Delias argenthona* Fabr. (Fam. Pieridae), underside.
12. *Delias mysis* Fabr. (Fam. Pieridae), underside.
13. *Terias hecabe sulphurata* Butl. (Fam. Pieridae).
14. *Ialmenus evagoras* Don. (Fam. Lycaenidae).
15. *Candalides xanthospilos* Hub. (Fam. Lycaenidae).
16. *Thysonotis hymetus salamandri* Macl. (Fam. Lycaenidae), male.
17. *Thysonotis hymetus taygetus* Feld. (Fam. Lycaenidae), female.



W. C. Davies photo.

AUSTRALIAN LEPIDOPTERA (RHOPALOCERA)

the Green Tree-Ant (*Oecophylla smaragdina* Fabr.) and is said to feed on the larvae and pupae of the ants.

The Arhopalinae are peculiar in having forewings with M_2 arising from above middle of cell, close to M_3. The only genus is *Arhopala*, which contains a few very beautiful species of moderate size, rich metallic blue or purple in colouring, with the hindwing tai'ed.

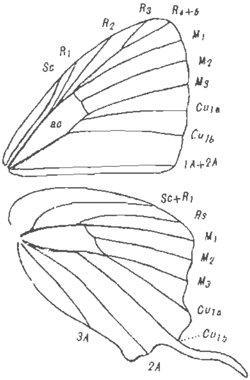


FIG. Z70. Wing-venation of *Ialmenus evagoras*. Don., Australia. Fam. Lycaenidae, subfam. Theclinae. Lettering as in fig. A8, p. 22, except *ac*, areocel. [*R. J. T. del.*

The Theclinae or Hairstreaks (fig. Z70) have the hindwing with an anal lobe more or less developed between 2*A* and 3*A*, and usually with one or more tails and a conspicuous eye-spot close to base of tail, thus producing the "double-headed" type of butterfly. This device is supposed to protect the insect from attacks by birds, who, thinking the tail and eye-spot indicate the head end, snap at it, and only get a piece of wing for their pains. *Ialmenus evagoras* Don. (pl. 44, fig. 14) is the commonest species, very pale, shining blue with black margins to wings, underside buff with black and red eye-spot. The larvae feed in the open on various Wattles (*Acacia*) and are attended by ants; the pupae are attached to webs spun by the larvae on the foodplant. *Pseudalmenus chlorinda* Blanch. is an interesting species with black wings marked with a narrow, subterminal, red band in hindwings, and peculiar in having R_{4+5} ending below apex of forewings. It has three well-marked races, and ranges from the Blue Mts. to Hobart. *Paralucia aurifera* Blanch. (pl. 40, fig. 8) is a brighter species extending from Queensland to Tasmania. *Deudorix* contains two fine tropical species, of which *D. epijarbas diovis* Hew. (pl. 40, fig. 5) is the best known; the female is dark brown. Other genera are *Protialmenus*, *Bindahara*, *Rapala* and *Hypolycaena*, all tropical except the first; the last named has two pairs of tails. The somewhat anomalous genus *Ogyris* contains fairly large species (expanding 35-50 mm.), whose larvae feed upon Native Mistletoe (*Loranthus*) and are usually attended by ants. The butterflies fly high and very swiftly, and many of them are beautifully coloured, deep metallic blue or purple, intensely brilliant. Some of the species are rare and tropical, but several, including the largest, *O. zosine* Hew., reach to Sydney or southwards of it; two or three extend to Western-Australia.

The Lycaeninae are an immense subfamily in which the anal lobe is absent; a tail is sometimes present. This group includes the majority of Blues and Cop-

pers. Most of the species are small in size but of quick flight. The genus *Miletus* contains a number of species, mostly with dull upper surface to wings, but the underside is ornamented with brilliant red and metallic spots. Most of them are tropical, but *M. ignitus* Leach, with its various races, extends from Cape York to Victoria and Western Australia; the larva feeds on wattle, living in the nests of species of *Iridomyrmex* at the base of the tree. *M. hecalius* Misk. (pl. 40, fig. 6) is a beautiful species found round Sydney. *Thysonotis* is a tropical to subtropical genus of very beautiful species showing strong sexual dimorphism; the underside has a subterminal band, rich metallic green. *T. hymetus* Feld. (pl. 44, figs. 16, 17) with three subspecies, extends from Cape York to the Richmond River; the males are purplish blue above, the females very pale blue with black border. *Nacaduba* contains small blue species, mostly with a slender, short tail to hindwings, mostly tropical, but the very small, tailless *N. biocellata* Feld. occurs all over Australia. The species of *Candalides* have pale underside to wings; the commonest is *C. xanthospilos* Hub. (pl. 44, fig. 15), with dark purplish wings and a large orange spot on forewings. *Neolucia* contains small species with dark brown or bronze-brown wings, the undersides strongly patterned. *N. agricola* Wwd. is very common; *N. hobartensis* Misk. is a much more local, alpine species. The Australian Copper, *Lucia lucana* Fabr. (pl. 40, fig. 7), is a very common species, rather dull in colour. The commonest species of the family is the little blue *Zizina labradus* Godart, also found in the North Island and Nelson Province of New Zealand, where it passes under the erroneous name of *Lycaena phoebe* Murray; in the rest of the South Island its place is taken by the closely allied *Z. oxleyi* Feld., with more conspicuously marked underside. New Zealand also possesses three species of Coppers allied to Holarctic forms and placed in the genus *Chrysophanus*. The commonest is the beautiful *Ch. sallustius* Fabr. (pl. 38, fig. 28), which has a bright yellowish-brown underside; its larva feeds on the climber *Muehlenbeckia*. The allied *Ch. enysi* Butl. is much darker and more spotted beneath, while the smaller *Ch. boldenarum* F.B.W. (pl. 31, fig. 34) is a local and very variable species, mostly metallic purplish above, but sometimes coppery brown.

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CHAPTER XXIX

FOSSIL RECORD AND ORIGIN OF THE AUSTRALIAN AND NEW ZEALAND INSECT FAUNAS.

THE record of the class Insecta, as preserved in its fossils, is that of the winged forms, or Pterygota, only. Although we can be certain that the Apterygota are the most ancient of existing insects, yet these delicate creatures have left no record in either Mesozoic or Palaeozoic rocks, and we do not know at what geological epoch they first appeared upon the earth.

As the skeleton of an insect is almost entirely external, and is composed of a non-cellular substance called *chitin*, which is very resistant to acids and alkalies, but dissolves slowly in water, it is seldom that the actual substance of the skeleton is preserved. Generally, the chitin of a fossilized insect has become changed through chemical action, and is often completely dissolved away, leaving only an impression of the insect on the rock within which it has become enclosed. Further, most insect fossils consist of isolated wings only, the chitin composing these being harder and more resistant than that of the body, and not exposed to the action of decay from the presence of the internal organs.

The earliest known fossil insects are those found in the lower part of the Upper Carboniferous of North America. At a somewhat higher horizon, in the upper part of the Upper Carboniferous, insects occurred abundantly both in North America and in Europe, the most famous beds being those of Commentry in France and Mazon Creek in America. The insects found in these beds are for the most part of large size, and are, as far as we know at present, entirely Ectopterygota or Hemimetabola. Many of them belonged to the extinct Orders Palaeodictyoptera, Protoblattoidea and Protorthoptera, but in some of the beds true Cockroaches (Blattoidea) were dominant, these being evidently at that period a new and highly successful specialization, which has continued to exist up to the present day with little modification.

The discovery of the Lower Permian Insect Beds of Kansas provides the connecting link between the Carboniferous "Age of Giant Insects" and the greatly modified Insect Fauna of the present day. In these beds, remnants of the Palaeodictyoptera and their huge allies the Protodonata (precursors of the true Odonata or Dragonflies) are found, together with a few Cockroaches and many specialized and reduced forms of Prothorthoptera. True Endopterygota or Holometabola are recognizable for the first time in very small species of the

Orders Mecoptera (closely similar to the Australian Choristidae of the present day) and Protohymenoptera (p. 256, fig. T8) ancestors of the true Hymenoptera. True Dragonflies of primitive Zygopterous form (p. 69, fig. F3) were also present, while numerous May-flies having four almost equal wings were a conspicuous part of the fauna. Orders ancestral to the Embiaria and Perlaria were represented, together with species belonging to the Hemiptera-Homoptera and Copeognatha.

Except for a few fossils found in the Upper Permian of Russia and the Trias of Germany, there was for a long time a great gap in the fossil record of the Insecta, the next beds of any importance being those of the English Lias, where the fauna is of quite modern aspect, composed chiefly of Beetles, Dragonflies, Scorpion-flies and the peculiar Orthoptera of the family Elcanidae.

The great gap between the Lower Permian and Liassic faunas has now been filled by the discovery in Australia of two fine insect bearing strata, viz. the Upper Permian Beds of Belmont and Newcastle, N.S.W., and the Upper Triassic Beds of Ipswich, Queensland.

The palaeontological record shows that Australia was probably the last of the great land-masses to receive a stream of immigrant terrestrial animals, and the absence of fossil insects from strata lower than the Upper Permian indicates that this was as true for the Class Insecta as for other classes of animals. As it is the purpose of this chapter to attempt to correlate the known geological history of Australia and New Zealand with the fossil record, as far as it has been discovered, and to supply an account of the probable sources from which the recent faunas of these two countries have been derived, we shall now deal with the different geological periods from the Upper Carboniferous onwards, reserving the accounts of the chief insect-bearing beds for the sections to which they geologically belong. As regards New Zealand, the fossil record is almost a complete blank. Some fossil insects of Oligocene age were discovered many years ago near Oamaru by Mr. Thomas Esdaile, who presented his collection to the Otago Museum. The insects, however, were never studied and remained undescribed, and this valuable collection appears to have been lost.

Upper Carboniferous and Lower Permian.

During this period temperate Australia was covered by an ice-sheet, and was probably separated from New Zealand by a narrow gulf between Tasmania and the South Island of New Zealand, both of which extended much farther out towards one another than they do to-day, and were probably connected far to the southward, the gulf being an arm of the sea which broke through the old Pacific coast-line far to the north, beyond New Caledonia. The conditions were therefore not favourable for the reception of a terrestrial fauna; and, as far as we know, no land-animals were present.

Upper Permian.

The Belmont and Newcastle Beds.

It was not until the Upper Permian that conditions in Australia first became favourable for the reception of a land fauna. The first terrestrial animals known to have existed in Australia belong to this period and the earliest known insects are those discovered by Mr.

John Mitchell, (late Principal of the Newcastle Technical College, N.S.W.) in the Upper Permian Coal Measures of Belmont and Newcastle. Though comparatively few in number, and requiring great labour and perseverance to discover, these fossils are for the most part very well preserved and form a most important link in the chain of evidence for the evolution of the Orders of Insects, as well as being one of the most valuable sources of evidence of the origin of the Australian Insect Fauna itself. Most of the specimens have been unearthed with great labour from a hard chert* in a small quarry near Belmont, on Lake Macquarie, the average rate of discovery being only a single insect wing to several days' hard work with the hammer. The associated flora is chiefly composed of species of *Glossopteris*, while a small Crustacean, *Leaia mitchelli* R. Eth., occurs in fair numbers in a narrow band very close to that occupied by the insect wings. The

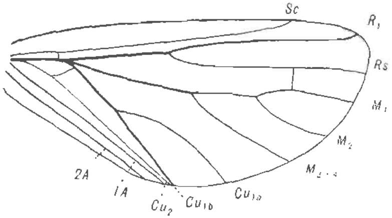

FIG. ZA1. *Pincombea mirabilis* Till., forewing. Fam. Pincombeidae. Order Hemiptera. Upper Permian of Belmont, N.S.W. Lettering as in fig. A8, p. 22. (*R. J. T. del.*

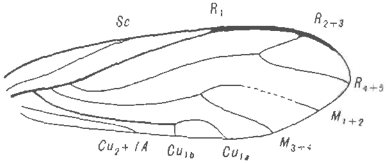

FIG. ZA2. *Lophioneura ustulata* Till., forewing. Fam. Lophioneuridae. Order Hemiptera. Upper Permian of Newcastle, N.S.W. Lettering as in fig. A8, p. 22. (*R. J. T. del.*

fauna contains the most specialized of all known Palaeozoic Insect Faunas and consists only of Hemiptera-Homoptera, Coleoptera, Mecoptera, Neuroptera-Planipennia, and two extinct Orders allied to the Coleoptera and Mecoptera respectively.

*Professor Sir Edgeworth David, F.R.S., has informed me that this chert is composed of an extremely finely divided volcanic tuff, largely built up of minute fragments of devitrified glassy lava. The insect bed at Denmark Hill, Ipswich, Queensland, is also composed of a fine-grained volcanic tuff. It seems clear that in both cases the insects were suffocated, borne down and covered over in hundreds by these tuffs, which must have been as fine as the finest flour. Insect remains should therefore be especially searched for in beds of this sort. Mr. B. Dunstan has seen enormous numbers of insects being gassed and petrified at the Einasleigh Hot Springs in N. Queensland, where carbonic acid and steam are liberated in large quantities.

The Homoptera were the dominant group, representing about half the total fauna. The Auchenorrhyncha were represented by a number of forms belonging to the extinct Scytinopteridae (closely allied to the Cercopidae) and the Prosbolidae (related to the Fulgoroid family

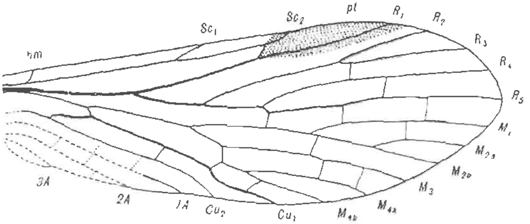

FIG. ZA3. *Permochorista sinuata* Till., forewing. Fam. Permochoristidae, Order Mecoptera. Upper Permian of Belmont, N.S.W. Letterings as in fig. A8, p. 22. (Dotted portion restored.)

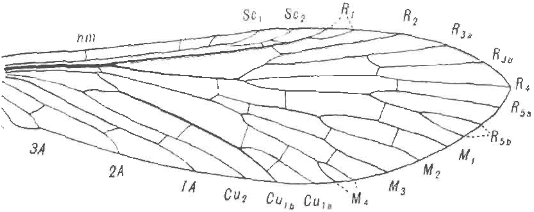

FIG. ZA4. *Belmontia mitchelli* Till., forewing. Fam. Belmontiidae, Order Paramecoptera. Upper Permian of Belmont, N.S.W. Lettering as in fig. A8, p. 22.

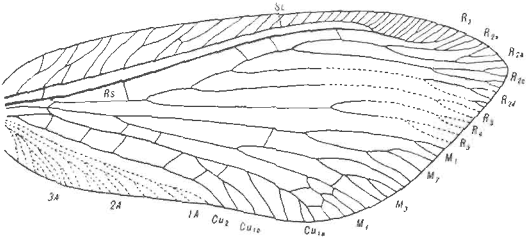

FIG. ZA5. *Permithone belmontensis* Till., forewing. Fam. Permithonidae, Order Neuroptera. Upper Permian of Belmont, N.S.W. Lettering as in fig. A8, p. 22. (Dotted portion restored).

[R. J. T. del.

Tropiduchidae). The Sternorrhyncha have two small but beautifully preserved forms, *Pincombea mirabilis* Till. (fig. ZA1) and *Lophioneura*

ustulata Till.* (fig. ZA2), each representing a family of its own; the former stands close to the point of departure of the original Sternorrhynchous stem from [illegible] Auchenorrhyncha, and is the only known type of the former with two complete anal veins; the latter is clearly ancestral to the Psylloidea.

The next most abundant group was the Mecoptera, represented by the single family Permochoristidae, with a number of species of the genus *Permochorista* (fig. ZA3). These insects were clearly the ancestors of the existing Australian Choristidae (pl. 26, figs. 1, 2), only differing from them in somewhat smaller size and in having *M* six-branched.

The Order Paramecoptera, confined, so far as at present known, to the Belmont Beds, is represented by two very fine wings, *Belmontia mitchelli* Till., (fig. ZA4) and *Parabelmontia permiana* Till., evidently related to the true Mecoptera, but having the general facies of wings of the Orders Trichoptera and Diptera, though with more than four branches both to *Rs* and to *M*. These wings undoubtedly represent the ancestral type from which the three Orders Diptera, Trichoptera and Lepidoptera later on arose (in the Trias or Lias), the Diptera being descended from forms having Cu_1 simple, as in *Parabelmontia*, while the common stem of the Trichoptera and Lepidoptera descended from forms having Cu_1 terminally forked, as in *Belmontia*; in both cases *Rs* and *M* became reduced to four branches before these Orders emerged as definite types.

The Neuroptera† are represented by a single fine Planipennian type, *Permithone belmontensis* Till. (fig. ZA5), which is the oldest known representative of this Order. It is evidently a specialization from the more generalized wing-type of the Paramecoptera, by addition of costal veinlets and terminal twiggings of the veins and by the formation of a pectinate series of branches on *Rs*.

Excluding the Coleoptera and Strepsiptera on the one hand, and the Hymenoptera on the other, the Endopterygote Orders known at the present day form a single complex or whole, previously called by me the "Panorpoid Complex," but perhaps more fittingly referred to as the Mecopteroid Orders, all of which have been evolved from the three closely related types illustrated by the Belmont fossil Mecoptera, Paramecoptera and Planipennia.

The Coleoptera are represented at Belmont by the earliest known fossil beetle-elytra, of which several species are known belonging to the genera *Permophilus* and *Permosyne*, the latter apparently closely related to the genus *Ademosyne* of the Ipswich Trias. *Permophilus* appears to have been directly ancestral to the recent *Hydrophilus*, while *Permosyne* is also probably closely related to the Hydrophilidae. Alongside these has been found a much larger elytron of very primitive type, much flattened, with straight sutural margin, and having a complete system of wing-veins strongly suggestive of the Protoblattoid type; between the veins the membrane is strongly pitted all over. This fossil, *Protocoleus mitchelli* Till., (fig. ZA6) clearly belongs to an Order ancestral to the Coleoptera as we know them to-day, though it cannot be one of their actual ancestors, since true Beetles existed alongside it. To this Order the name Protocoleoptera† is given. The true Coleoptera

*This fossil comes from Merewether Beach, at a horizon probably about 500 feet lower than that of the Belmont Insects.

†Other representatives of these Orders have been discovered at Belmont since this was written; see footnote to p. 480.

probably arose from it by reduction in size, with consequent simplification and finally loss of the venation, together with a progressive increase in the convexity of the elytron, with correlated curving of the sutural margin. At the same time, as the true veins died out, the fine pits lying on the membrane between them became more or less aligned, resulting in the formation of the primitive *punctate striae* found in nearly all the oldest fossil Coleoptera elytra. The courses of the original veins are therefore represented in the true beetle elytron by the raised *intervals between the striae.*

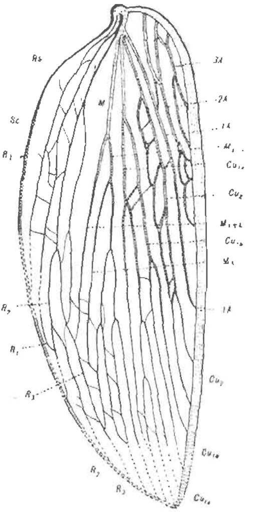

FIG. ZA6. *Protocoleus mitchelli* Till., elytron. Fam. Protocoleidae, Order Protocoleoptera. Upper Permian of Belmont, N.S.W. Lettering as in fig. A8, p. 22. Sculpture of the membrane omitted. Dotted portion restored. [*R. J. T. del.*

The *Glossopteris*-flora, with which these insects are associated, takes its name from the dominance of the genus *Glossopteris.* This type of flora was characteristic of Upper Permian times in South America, South Africa, India, Australia and Antarctica; but it has not yet been proved to have existed in New Zealand at that time. The presence of this common flora indicates that all these land areas, lying chiefly in the Southern Hemisphere, were connected about that time, and the whole area of land which possessed this flora is called Gondwanaland.

The first insect fauna, then, received by Australia was a Gondwanaland fauna, and may be distinguished by the term "Early Austro-Gondwanan." Its remains may still be recognized in Australia to-day in the form of a group of plant-hoppers (Tropiduchidae), the scorpion-flies of the family Choristidae, and the moth-lacewings or Ithonidae. These groups are all absent from New Zealand.

TRIASSIC.

THE UPPER TRIASSIC BEDS OF IPSWICH, QUEENSLAND.

It is important to recognize that, in South-Eastern Australia, there was no definite stratigraphical break between the Upper Permian and Lower Triassic, the division being made at the line of strata where the flora changed and *Glossopteris* disappeared. The Passage Beds between Upper Permian and Lower Trias are exposed in the collieries of Sydney Harbour and Bulli. From the roof of the coal-seam in the former colliery a single insect-wing has been discovered, viz. *Elcanopsis*

sydneiensis Till., belonging to the Orthopterous family Elcanidae, characteristic of the European Lias.

Owing to the continuity of the strata and the prevalence of lacustrine and otherwise suitable conditions over a long period of time, we may assume that the early Gondwanan fauna, received in Upper Permian times, continued to inhabit Australia, though we have no fossil records of it until we come to the Upper Triassic*. At that time, Australia, Tasmania, and most of Papua formed a huge land-mass stretching far to the west of Western Australia, and also covering the area between Queensland and the Solomon Islands, New Caledonia and the New Hebrides, which formed the then eastern boundary of the Pacific Ocean. A long tongue of land ran down from the New Hebrides west of New Zealand, perhaps enclosing the south-western corner of the South Island, and separated from the Australian portion by a large gulf running up as far as the South Queensland coast. Most of New Zealand was still submerged. Lakes of large extent were present in south-eastern Queensland, a considerable part of New South Wales, and over at least the eastern half of Tasmania.

The insect fauna of this land-mass appears to have been a later development of the earlier Gondwanan fauna, enriched by many new types. It is preserved to a large extent in the fossil beds of Ipswich† (Queensland) and St. Peter's (Sydney). The first discovery of fossil insects at Ipswich was made by Mr. T. H. Simmonds of Brisbane, the insects being described by Messrs. Etheridge and Olliff in 1890; these fossils were chiefly beetle elytra. Later, Mr. B. Dunstan, Chief Government Geologist of Queensland, explored the beds more systematically, and has succeeded in obtaining nearly 200 specimens, from which about 120 species have now been described.

In the Ipswich Fauna, the same elements are to be recognized as in the older Belmont Fauna, viz. Hemiptera, Coleoptera, Mecoptera, Planipennia and allies, but a great advance in specialization is to be noted. The Hemiptera have increased in number and variety, and are represented both by Heteroptera and Homoptera. In the Heteroptera.

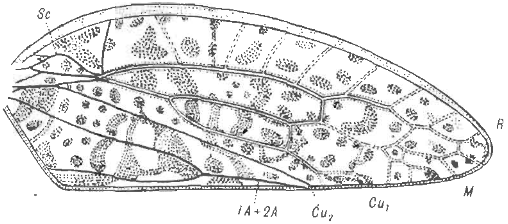

FIG. ZA7. *Ipsvicia jonesi* Till., tegmen. Fam. Ipsviciidae, Order Hemiptera. Upper Trias of Ipswich, Q. Lettering as in fig. A8, p. 22.
[R. J. T. del.

*Since this was written, a fine wing belonging to the genus *Mesotitan* (known also from Upper Trias of St. Peter's, Sydney) has been discovered by Mr. Scully in the passage-beds between Lower and Middle Trias at Beacon Hill, near Deewhy, N.S.W. This genus contains enormous insects expanding up to 11 inches and almost certainly belonging to the very rare Order Protohemiptera, otherwise known only from the Lower Permian of Germany.

†See footnote on p. 470.

the family Dunstaniidae belongs to the Gymnocerata, and is clearly an early type ancestral to the Pentatomoidea, while the Triassocoridae belong to the Cryptocerata, and are ancestral to the Notonectoidea. In the Homoptera, Auchenorrhyncha are dominant, the Scytinopteridae being abundant, while true Jassidae and early Fulgoroidea of the extinct family Ipsviciidae (fig. ZA7), probably ancestral to the recent

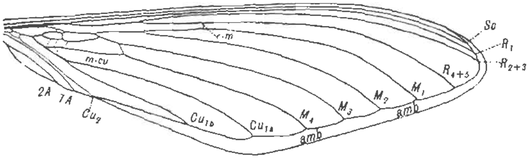

FIG. ZA8. ***Mesogereon superbum*** Till., tegmen. Fam. Mesogereonidae, Order Hemiptera. Upper Trias of Ipswich, Q. Lettering as in fig. A8, p. 22, except *amb*, ambient vein; *m-cu*, medio-cubital cross-vein; *r-m*, radiomedian cross-vein. Sculpture of membrane and coriaceous border omitted. (*R. J. T. del.*

Tettigometridae, were also present. The most beautiful of all the fossil Homoptera are, however, the large Mesogereonidae, (fig. ZA8) ancestral to the Cicadidae, of which several species occur at Ipswich.

The Coleoptera at Ipswich outnumber the Hemiptera in species, though not in variety of forms. It seems almost impossible to place fossil elytra in known families with any certainty, but the abundant species of the genus *Ademosyne* and allies, of which several more or less complete fossil forms are known, may be put with a very high degree of probability into the family Hydrophilidae.

The Mecoptera are represented by two genera closely allied to the existing Australian *Chorista* and by a very large form, *Archipanorpa magnifica* Till., belonging to a distinct suborder Protomecoptera, and

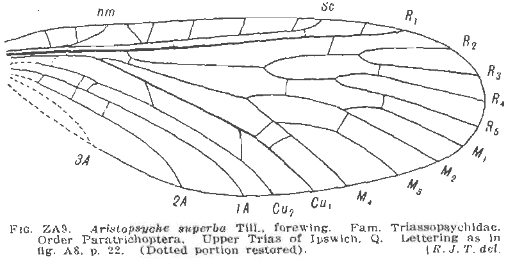

FIG. ZA9. ***Aristopsyche superba*** Till., forewing. Fam. Triassopsychidae. Order Paratrichoptera. Upper Trias of Ipswich, Q. Lettering as in fig. A8, p. 22. (Dotted portion restored). (*R. J. T. del.*

allied to the still existing genus *Notiothauma* of Chile. The preservation of this fossil is so perfect that the sockets of every hair and bristle on the wing are plainly visible.

The Paramecoptera of the Belmont Beds are represented at

Ipswich by reduced types placed in a new Order Paratrichoptera and *closely resembling true Diptera except in the absence of any narrowing* of the base of the wing or reduction in the anal venation. Four genera are represented, of which the finest is *Aristopsyche* (fig. ZA9). They differ from true Trichoptera chiefly in the simple form of Cu_1 and the absence of any looping-up of the anal veins.

The Neuroptera-Planipennia are well represented by some fine genera belonging to the Psychopsidae and the related but now extinct family Prohemerobiidae. All of them show a great advance in specialization over *Permithone*. The fine *Triassopsychops superba* Till., (fig. ZA10) would appear to be the direct ancestor of *Megapsychops illidgei* Frogg. (pl. 23, fig. 2), which still exists within fifty miles of the place where this fossil was found.

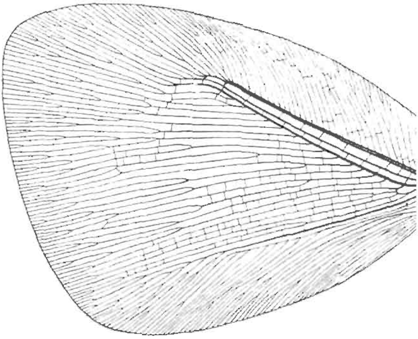

FIG. ZA10. *Triassopsychops superba* Till., forewing. Fam. Psychopsidae. Order Neuroptera. Upper Trias of Ipswich, Q. [*R. J. T. del.*

In addition to the above-mentioned Orders shared in common with the older Belmont Beds, the Ipswich Trias is rich in additional elements, which evidently reached Australia (probably from the North) during the intervening period. Curiously enough, these all belong to older Ectopterygote Orders, viz. the Odonata, Orthoptera (including a number of Blattoidea) and a few representatives of the older Carboniferous Orders.

The Protorthoptera are represented by the two genera *Mesomantidion* and *Mesorthopteron*, the latter genus being quite common, judging by the large number of fragments of the wings of *M. locustoides* Till. already discovered; it is unique in the remarkably rich branching of Cu_1.

True Orthoptera were represented by species of the genera *Triassomantis* and *Triassolocusta*, together with several fine species of Cockroaches closely related to European Liassic types.

Several genera of true Dragonflies were present at Ipswich. Most of the wings are fragmentary, but the two in which the basal portion is preserved are both of true Zygopterous type and serve to link up recent Zygoptera with the Lower Permian *Kennedya* (p. 69, fig. F3). *Triassagrion* had a very short *Sc* with two antenodals, a well-formed pterostigma and an incomplete arculus, but differed from *Kennedya* in the much larger numbers of postnodals and wing-cells. *Triassolestes* agrees with *Kennedya* in having no anal area, but the arculus is complete, a closed discoidal cell with acute distal angle being present (fig. F4, A).

[illegible]

of wing so utterly unlike anything else known that a separate Order Aëroplanoptera must be made to receive it. Possibly it is an offshoot of one of the old Carboniferous Orders.

The Wianamatta Shale (Upper Triassic) has yielded insect remains both from the brick-pits of St. Peter's, near Sydney, and from Narellan and Glenlee, N.S.W. Beetle elytra predominate at both horizons, the Ipswich genus *Ademosyne* being represented at Narellan. Both beds have also yielded some large Protorthoptera allied to those found at Ipswich, the best preserved genus being *Notoblattites*. The associated flora at Ipswich was a typical Mesozoic assemblage of ferns, cycads, and equisetales. The associated fauna at St. Peter's consisted of a huge Labyrinthodont, numerous freshwater fishes, the Isopod crustacean *Phreatoicus*, some Ostracods, the bivalve molluscs *Unio* and *Unionella*, and various Foraminifera; but at Ipswich only the small crustacean *Estheria* has so far been found. Existing remnants of this insect-fauna can be recognized in certain archaic types of damsel-flies such as *Synlestes*, *Chorismagrion*, and *Hemiphlebia*, the Orthopterous Perlamantinae, the Cupidae and perhaps other families amongst the beetles, and the family Psychopsidae amongst the lacewings. This last family and the Synlestidae still have a Gondwanan distribution, being found only in Africa, India and Australia.

This Upper Triassic insect fauna of Australia, then, may be distinguished as a "Late Austro-Gondwanan fauna."

Jurassic.

In the Lower and Middle Jurassic the large land-area mentioned in the Upper Trias contracted on the west but expanded on the east, including a large part of the South Island of New Zealand. A large lake covered eastern Tasmania, and a very much greater lake occupied most of Queensland, with an outlet to the north. It was probably during this period that New Zealand received her first insects, and perhaps also the tuatara. The sea covered the western shores of the Australasian continent, but oscillated over the eastern, with a general tendency to retreat, thus gradually enlarging the terrestrial connection between the Australian and New Zealand areas. Thus the same groups of insects which reached New Zealand in Jurassic times also entered eastern Australia. These were chiefly the more archaic Orthoptera, Coleoptera, and perhaps Diptera, common to the two, together with a few Trichoptera and Lepidoptera Homoneura.

In a marine bed of Upper Jurassic Age (Rolling Downs Series) near the Flinders River, Queensland, a fine dragonfly wing, *Aeschnidiopsis flindersiensis* Woodward, has been found by Mr. R. L. Jack. This insect belongs to the extinct family Aeschnidiidae, characteristic of the European Upper Jurassic.

Cretaceous.

The period extending from Upper Jurassic to Middle Cretaceous was notable for the separation of Australia into two distinct land-masses by a wide arm of the sea, reaching from the Gulf of Carpentaria on the north to the Lake Eyre basin and the Australian Bight on the south. Western Australia thus became a separate continent, in connection with lands which had also access to Madagascar and perhaps South Africa. From this connection Western Australia received her peculiar flora, at a time when the separation from Eastern Australia was operative. Some groups of insects having African and Madagascan

affinities reached Western Australia at this time, notably the Nemopteridae or thread-winged lacewings, and other representatives of the Planipennia, in which Western Australia is remarkably rich. The Buprestidae amongst the beetles also probably reached Australia by this route, and spread later on to the east.

While Western Australia was separated off, Eastern Australia extended over the Tasman Sea to include Tasmania, New Zealand, New Caledonia, and even the Fiji Islands, and there was also a broad extension southwards, giving, at any rate for a time, a connection with Antarctica. This connection affected Eastern Australia and New Zealand about equally and supplied both with a number of types of cold-climate and aquatic insects which form a very distinct element of both faunas at the present day, and are chiefly confined to New Zealand, Tasmania, and the mountains of Eastern Australia. The chief representatives of this fauna are the whole of the May-flies except the Baëtidae, the Petaliine and probably also the Petalurid dragonflies, the whole of the Stone-flies except perhaps the Nemouridae, a number of Caddis-flies, the small Scorpion-flies of the family Nannochoristidae, and a number of Nematocerous Diptera, including the Tanyderidae, Blepharoceridae, Simuliidae, Psychodidae, and many Tipulidae.

Upper Cretaceous and Early Tertiary

During the Upper Cretaceous the sea again began to encroach as a gulf between Tasmania and New Zealand, the western and eastern halves of the Australian Continent were reunited with a large lake in the centre, and Australia was connected on the north with Papua and on the north-west with Timor and Malaya proper. The gulf between Tasmania and New Zealand grew in size, reaching farther and farther northwards as a long arm of the sea right up to North Queensland. During this time New Zealand undoubtedly received the greater part of its insect fauna in the form of a stream of immigrants from the north, which passed down through New Caledonia by a continuous land-mass. A closely similar type of fauna poured into eastern Queensland. This accounts for the many strong relationships shown between the faunas of New Zealand and of the tropical and subtropical forests of the Queensland and New South Wales coasts.

Somewhere in early Tertiary times it appears that New Zealand was finally severed from its northward connection with the main Australian land-mass, and probably also from that with Antarctica. The stream of insect immigrants continued to pour into Australia in ever-increasing numbers, but none of the later groups reached New Zealand. This explains how it is that New Zealand is devoid of so many of the higher families of insects. The rich Australian fauna of butterflies, and most of the higher families of moths, most of the higher Hymenoptera, many striking groups of beetles such as the Cetoniinae, many fine cicadas and other Homoptera, and the Libellulid dragonflies, all came this way, and all were shut out from New Zealand.

In the early Tertiary, Australia was taking form as we know it at present, and a dry continental climate had to a great extent developed. New Zealand, on the other hand, though probably more extensive than at the present day, was never large enough to have developed more than comparatively limited areas of land with a continental climate, as in Central Otago. Thus, for the most part, the New Zealand bush still

shows clearly enough its tropical origin, and the insects which came in with it have altered but little. In Australia, on the other hand, a very large and typical xerophytic flora and fauna was developed, to which the great majority of Australian insects of the present day belong. It is this fauna, more than any other, which marks off the Australian insects as distinct from those of all other known faunas, and gives to them their most striking peculiarities.

There still remain to be accounted for those highly specialized, cold-climate groups which we find centred in Tasmania and the South Island of New Zealand, but which are not archaic enough to have entered by means of the Antarctic connection in earlier Mesozoic times. In studying these we are struck with the very great differences, not only in the types of insects which reached Tasmania and New Zealand respectively about this time, but also in the associated flora and fauna. This leads us to postulate two separate connections with Antarctica in early Tertiary times.

The earlier of these, which we may call the "penultimate Antarctic connection," appears to have been a connection with New Zealand only. The outstanding elements of the flora received through this connection are the species of native beech (*Nothofagus*) and Fuchsia trees. In the fauna, the *Placostylus* snail is the most striking component; but a number of interesting insects must also be included, such as the alpine Satyrine butterflies, some striking Noctuidae and Geometrites, and a few Arctiidae, chiefly confined still to the South Island.

A somewhat later connection took place between Antarctica and Tasmania, after the New Zealand connection had been severed. This may be designated as the "last Antarctic connection"; it probably existed in the Miocene. The Native beech (*Nothofagus*) was a component of its flora, as of the earlier connection, but no fuchsias reached Tasmania. The insect fauna is represented by much the same groups as in the case of the earlier New Zealand connection, but in no case are the genera the same. With the Satyrine butterflies may also have come one or two Hesperiidae and Lycaenidae.

Australian Tertiary Fossils

Very few Tertiary fossil insects have so far been found in Australia, and in most cases the exact horizon of the beds has not been determined. Etheridge and Olliff (1890) described some larval remains from Vegetable Creek, N.S.W. A dragonfly larva of the family Lestidae was found in the core of the Duaringa Bore in Queensland. From the Tertiary of Goodna, Queensland, two fine wings have been described, viz. *Euporismites balli* Till. (Order Neuroptera, fam. Osmylidae) and *Scolypopites bryani* Till. (Order Hemiptera, fam. Ricaniidae). The most interesting discovery is the wing of *Austrodictya corbouldi* Till., (Order Orthoptera, fam. Tettigoniidae), probably of late Tertiary age, which was found embedded in a large crystal of selenite enclosed in the copper lode of the Mount Elliott mine, North Queensland, at a depth of 260 feet below the surface; such a position for a fossil insect wing is unique.

Tasmania.

Tasmania remained a part of Australia until late Tertiary times, but was probably divided from and reunited with the mainland several times before its last very recent severance. Thus it received a great

part of those insects of northern origin which worked their way as far south as Victoria and South Australia. Most of the tropical and subtropical groups are, however, absent, especially those representative of the latest stream of immigration from the north. We may mention *Papilio macleayanus* and some of the large cicadas as insects of northern origin found in Tasmania. Tasmania, however, holds the largest share of the immigrants received through the Antarctic connections, and this gives its fauna its somewhat remote relationship with that of New Zealand. The great majority of insects found in Tasmania are closely related to those of southern Victoria, the faunas of these two areas being very similar.

New Zealand.

From the evidence, we may conclude that the insect fauna of New Zealand may rightly be considered as belonging to that of the Australian region, seeing that it has originated from sources which also supplied other parts of that region. New Zealand, however, had little or no access* to the Gondwanan faunas which first populated Australia, nor had she a sufficiently late connection with the north to receive the mass of representatives of the highest groups of insects which poured across into Australia. Nor, again, had she sufficient development of large continental areas to allow of the formation of a striking autochthonous fauna of a xerophytic type such as we find in Australia itself. Thus while we notice in the New Zealand fauna resemblances with that of Tasmania on the one hand, through the unions with Antarctica, and with that of Queensland on the other, through the northward union with Australia and Papua, we must remember that the earliest and latest of the Australian immigrant groups are absent. Though no fossil insects have yet been discovered in New Zealand earlier than Oligocene, such should certainly occur somewhere in Jurassic or later strata.

This chapter may profitably be concluded with three Tables, (1) showing the succession of geological epochs and periods from the present day to the earliest known strata, with remarks on the first recorded occurrences of the more important Orders, etc., (2) showing the known sources of the present Australian and New Zealand Insect Faunas, and (3) showing the compositions of the fossil insect faunas of the Upper Permian of Belmont†, N.S.W. and of the Upper Triassic of Ipswich, Queensland.

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*The presence of the peculiar Isopod Crustacean *Phreatoicus* in New Zealand perhaps indicates some such access in Upper Triassic times.

†Since this chapter was written, Mr. Mitchell has worked out the horizon of the Belmont Beds from the succession of strata exposed in the shaft of the new John Darling coal-mine, which is now being sunk almost exactly on the spot where the wing of *Belmontia mitchelli* Till. was discovered. He finds that this horizon is only about 300 feet below the top of the Palaeozoic strata, or considerably higher than was at first estimated. This would account for the high specialization of the fauna, which is much more closely related to the Upper Triassic fauna of Ipswich, Queensland, than it is to any known Palaeozoic fauna. Many more fossil insects have recently been found, both at Belmont and at Warner's Bay (at about the same horizon). The complete fauna will be dealt with by me in a series of papers to be published in *Proc. Linn. Soc. N.S.W.* after the appearance of this book. The census numbers given in the Table on p. 482 for these beds have been brought up to date by including all the new forms awaiting description in these papers.

TABLE SHOWING THE SUCCESSION OF GEOLOGICAL EPOCHS AND PERIODS WITH FIRST RECORDED OCCURRENCES OF THE MORE IMPORTANT ORDERS OF INSECTS.

EPOCH	PERIOD		REMARKS
QUATERNARY or RECENT			
TERTIARY or CAINOZOIC	PLEISTOCENE PLIOCENE MIOCENE		Insect Fauna closely similar to that of Recent Times.
	OLIGOCENE EOCENE		First recorded LEPIDOPTERA (Lower Oligocene).
SECONDARY or MESOZOIC	CRETACEOUS JURASSIC	Upper Jurassic	First recorded HYMENOPTERA.
		Liassic	First recorded DIPTERA and TRICHOPTERA.
	TRIASSIC		PARATRICHOPTERA (four-winged ancestors of Diptera) existed in Upper Trias.
PRIMARY or PALAEOZOIC	PERMIAN	Upper	First recorded COLEOPTERA, NEUROPTERA and HEMIPTERA. PROTOCOLEOPTERA (ancestors of Coleoptera) and PARAMECOPTERA (ancestors of Lepidoptera, Trichoptera and Diptera) existed.
		Lower	First recorded MECOPTERA, ODONATA, PLECTOPTERA, HEMIPTERA and COPEOGNATHA. PROTOHYMENOPTERA (ancestors of Hymenoptera) existed.
	CARBONIFEROUS	Upper	First recorded occurrence of Winged INSECTA, of which the only group still existing to-day is the Cockroaches (BLATTOIDEA, Order ORTHOPTERA). Principal extinct Orders were PALAEODICTYOPTERA, PROTODONATA, MEGASECOPTERA, PROTOHEMIPTERA, PROTORTHOPTERA and *PROTOBLATTOIDEA*.
		Middle Lower	
	DEVONIAN SILURIAN ORDOVICIAN CAMBRIAN ARCHAEAN		No known Fossil Insects.

TABLE SHOWING THE KNOWN SOURCES OF THE PRESENT AUSTRALIAN AND NEW ZEALAND INSECT FAUNAS.

	Faunal Element.	Geologic Period.	Australia.	New Zealand.
1.	Early Austro-Gondwanan	Upper Permian	Present	Absent
2.	Late Austro-Gondwanan	Upper Triassic	Present	Absent
3.	Early Austro-Malayan	Jurassic	Present	Present
4	Early Antarctic	Jurassic	Present	Present
5.	Western Australian	Cretaceous	Present	Absent
6.	Middle Austro-Malayan	Upper Cretaceous to Early Tertiary	Present	Present
7.	Penultimate Antarctic	Early Tertiary	Absent	Present
8.	Last Antarctic	Middle Tertiary (?Miocene)	Present	Absent
9.	Autochthonous (xerophytic)	Tertiary	Present, dominant	Present, slight
10.	Late Austro-Malayan	Late Tertiary	Present	Absent

TABLE SHOWING THE COMPOSITIONS OF THE FOSSIL INSECT FAUNAS (AUSTRO-GONDWANAN) OF THE UPPER PERMIAN OF BELMONT, NEW SOUTH WALES, AND OF THE UPPER TRIASSIC OF IPSWICH, QUEENSLAND.

Order or Suborder.	Upper Permian of Belmont, N.S.W.		Upper Triassic of Ipswich, Q.	
	Species.	Percentage.	Species.	Percentage.
Aëroplanoptera	—	—	1	0.8
Odonata	—	—	4	3.3
Protorthoptera	—	—	2	1.6
Orthoptera	—	—	12	9.8
Blattoidea	—	—	8	8.2
Mantoidea	—	—	1	0.8
Acridioidea	—	—	1	0.8
Hemiptera	28	45.2	34	27.9
Heteroptera	—	—	7	5.7
Homoptera	28	45.2	27	22.2
Protocoleoptera*	6	9.7	—	—
Coleoptera	11	17.7	58	47.6
Mecoptera	11	17.7	3	2.4
Paramecoptera	2	3.2	—	—
Neuroptera (Planipennia)	4	6.5	4	3.3
Paratrichoptera	—	—	4	3.3
Total	62	100.0	122	100.0

*The genus *Permofulgor*, with three known species, originally placed by me in the Homoptera, is found from the latest and most complete specimen to belong to this Order and is included in it in this census.

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CHAPTER XXX

COLLECTION, PRESERVATION, AND STUDY OF INSECTS

In this chapter a brief account is offered of the more important methods in use in the collecting, preserving and scientific study of insects. A good collection is absolutely necessary as the basis for systematic and morphological work on any group of Insects; yet it must be borne in mind, at the same time, that the knowledge gained in the course of accumulating such a collection, i.e. by observation in the field of Nature herself, is equally important to the student. The careful observer will attempt to put on record, in the form of entomological notes or a natural history diary, all the more important details of each day's field-work; at the same time, he will value his "catch" sufficiently highly to give it that amount of care and preparation which will make it most suitable as material for useful scientific work on those lines along which his own personal researches may be directed.

FIELD-WORK.

The entomologist can find work to do in the field all the year round, but different months of the year will offer a maximum or minimum of reward according to the latitude and the climate in which he lives. In New Zealand, the principal collecting months are from October to April inclusive; December, January and February include between them the very best of the season and practically the whole of the alpine collecting. Much the same may be said of Tasmania. On the mainland of Australia the distribution of the rainfall is one of the principal factors in determining good or bad months; within the Tropics, it is generally true that the best collecting season comes just after the monsoonal rains, April, May and June being usually excellent months in North Queensland, while the spring months, August, September and October, are frequently very poor owing to long-continued shortage of rain. Further south, in the subtropical and warmer temperate latitudes, the spring months, August to November, include the best part of the collecting, but vary greatly according to the amount of rainfall which has preceded them. In these latitudes, collecting is often poor at midsummer during great heat and drought, but may revive again in March, April and May. In the latitude of Sydney there are always some insects on the wing all the year round, and the winter months, June, July and August, are some of the very best for certain Orders, e.g. Collembola and Perlaria. For high altitude collecting in Australia, the best season is the same as in New Zealand, viz. December to February.

As regards time of day, the best collecting is usually done in the morning, from 10 a.m. to 1 p.m. On very hot days, good catches may be made even earlier than 10 a.m., and the methods of beating and sweeping yield excellent results at early hours, when most insects are still too sluggish to attempt to escape from the net or umbrella.

The Net:—For most types of field-work, a net is essential. The type of net to be used depends upon the type of insects sought. For large, strongly flying insects, such as Lepidoptera and Odonata, a Kite-net is most useful; this is made in four pieces and a Y, so that, when fitted together, the outline of the net is that of a kite with its upper half semi-circular and its lower half triangular. A good size for Odonata is about 2 feet from Y to apex; for Lepidoptera a somewhat smaller size, 18 inches or so in length, will suffice. The handle of such a net should be light, strong and well-balanced, and should fit tightly enough into the Y to prevent any twisting of the net during the hardest strokes; four feet is quite long enough for the handle, and some collectors prefer it considerably shorter. For collecting smaller insects, a circular net of diameter 12 or 14 inches is most suitable, with a handle two feet long; such a net may be made in one piece, or else hinged at one or two points to allow of folding up; it may have a Y, or be constructed with a screw attachment to fit into a ferrule on the end of the handle.

For beating and sweeping, a strong net is required of about 12 inches diameter, preferably made in one piece, and with a stout handle; most of the nets put on the market for these purposes are unsatisfactory or wear out quickly, and it is not easy to make one which will stand the wear and tear required of it in the rougher types of country both in Australia and New Zealand.

The net-bag should be made deep enough to allow of a good over-fold in which to hold the insect at the end of the stroke, but not so deep that the operation of bottling or boxing the specimen becomes unwieldy. For a kite net, the overfold should be about the same length as the transverse diameter or a little less; for a beating-net of a foot diameter, 18 inches total depth will suffice. The bottom of the bag should be gently and broadly rounded, not coming to a point or cut off squarely. Mosquito netting of good quality is suitable as a material for the larger nets, provided insects of very small size are not being collected; but, for retaining insects of all sizes, Brussels net must be used. The bag should always be affixed to the rim by a calico casing about 2 inches wide, with a sufficient slit or plaquet opposite the Y or ferrule to allow of its being slipped on or off the framework of the net with ease.

Some collectors use the beating or sweeping-net with a bag carrying a pointed apex ending in a small circular hole supplied with a running tape, so that a strong glass tube can be affixed by tying the tape round its neck. When this tube is full of small insects and vegetable débris from sweeping, it is removed and fitted into the cork of a special type of killing-bottle (see p. 487) and a fresh tube takes its place.

An ordinary umbrella is preferred by many to the sweeping or beating net. The umbrella is inverted beneath a bush or branch of a tree, which is then beaten vigorously with a stick. Many insects feign death and can be bottled at leisure, but others attempt to get away

quickly and may be very difficult to capture in this manner. The umbrella has the great advantage of its wide diameter as compared with that of the net, and the insects which fall into it are easy to see.

Forceps:—Two types of forceps are needed (a) a light, springy pair with straight, slender points, delicately ribbed on the inside, for handling and sorting dead insects before setting, and (b) a stronger pair, with broader, truncated ends strongly curved, also ribbed on the inside, for setting. The former should have their points inserted into a cork when being carried in the pocket; the latter may be conveniently enclosed in a leather or cloth sheath. Care should be taken, in purchasing the setting forceps, to test them on a number of pins of varying sizes, to see that they can give a firm grip and will pick a pin up without causing it to skip; the type of grip depends on the care with which the ribbing or milling of the inside surface has been carried out.

Collecting-tubes, pill-boxes and paper-triangles:—For the purpose of containing the insects when captured, the most generally useful apparatus are glass tubes, pill-boxes and paper-triangles. Glass tubes should be of strong make, either cylindrical or with a wide neck, and should have well-fitting corks; if used in conjunction with the type of killing-bottle shown in fig. ZB2, B, they must all be of the same diameter. One set may be kept dry, another set may be filled with fixative or 70 per cent. alcohol, into which delicate insects like Thysanura, Collembola and Thrips may be placed at once. *Pill-boxes* should be of the *glass-bottomed* type, obtainable in nests of three or four different sizes. *Paper-triangles* may be made from ordinary typing-paper; many kinds

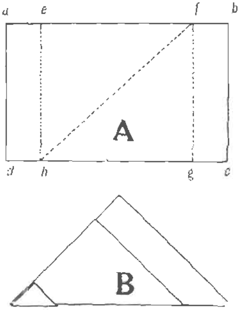

FIG. ZB1. Diagram to show method of folding a paper triangle. In A, the dotted lines indicate the creases to be made. Fold the paper first along *fh*; then fold the edges over along *eh* and *fg*, the final result being as shewn in B.
[*R. J. T. del*

of larger insects whose wings fold flatly backwards can be conveniently carried in them as soon as killed, and Dragonflies should be placed alive in them. They are also of great use in storing duplicate specimens, and in sending insects through the post.

Zinc Relaxing-box:—Many collectors, especially Lepidopterists, carry with them a small zinc relaxing-box lined with cork, which is

kept slightly moist (the addition of a little thymol will prevent mould from forming); each specimen, as soon as killed, is pinned into this box, and is thus brought home in fresh condition and ready for setting.

Killing-bottles:—The best type of killing-bottle is either wide-necked or cylindrical and made of strong glass; the cork also should be cylindrical (not sloping inwards so as to leave a narrow gap between itself and the top of the bottle). For large size, 5½ inches in length by 2 inches diameter is suitable. This should be charged with potassium cyanide in small lumps set into a mass of plaster-of-Paris about 1¼ inches deep, and covered over with several circular discs of blotting-paper cut so as just to fit the bottle; above this, the bottle should be half-filled with crumpled pieces of soft tissue paper to prevent the insects rubbing against one another. *Always keep a separate killing-*

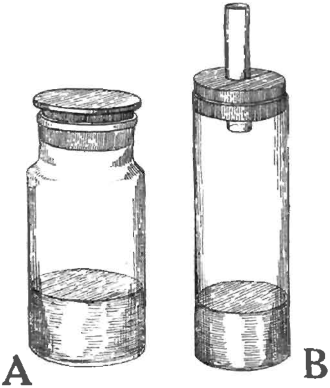

FIG. ZB2. Two good types of killing-bottle. A, ordinary wide-necked cyanide bottle, 4½ x 2 inches, with wooden-topped cork. B, cylindrical killing-bottle, 5½ x 2 inches, with glass-tube fitted through hole in cork. [P. Tillyard del.

bottle for Lepidoptera only, as otherwise the scales come off and attach themselves to the wings and bodies of other insects; it is also a good plan to keep a separate one for Coleoptera and Hemiptera, since many of these exude strong-smelling liquids or vapours before dying and thus make the bottle unsuitable for other insects. An excellent type of killing-bottle is one in which the cork is pierced with a circular hole made to carry a glass tube of given size and make (fig. ZB2, B); a set of such tubes is carried in the pocket or in a collecting-bag, and one may also be attached to the net-bag as described on p. 485; when these tubes are full, or at any convenient moment during a rest, the insects in them can be transferred one by one to the killing-bottle simply by placing the tubes in turn into the cork of the bottle, open end downwards.

Many collectors prefer either to collect all their insects alive in

tubes and pill-boxes, or else to keep the larger and more important specimens alive in this manner, while using one or two smaller killing-bottles for the smaller insects. Such bottles are best made from stout glass tubes with well-fitting corks, two good sizes being 4 inches long by 1 inch diameter and 3 inches long by ¾ inch diameter; each one should be charged with a small lump of potassium cyanide plugged down to bottom with cotton-wool and moistened with a single drop of water before use; cover surface of cotton-wool with several discs of blotting-paper to fit tube exactly. Or they may be charged with a few drops of *acetic ether* (ethyl acetate), added fresh each day of use, and kept from touching the insects by being well plugged down with cotton-wool and blotting-paper.

In killing elongate insects or larvae in a liquid medium, such as fixative or 70 per cent. alcohol in a tube, lay the tube down horizontally after corking it up, so that the insect dies extended instead of coiled up.

Fixatives for killing:—For ordinary specimens to be killed in liquid medium, either 70 per cent. alcohol or else a 4 per cent. formalin solution (40 per cent. formaldehyde, 1 part; water, 10 parts) may be used. A more satisfactory fixative is that known as Blés Solution, having the following formula:—

70 per cent. alcohol - - -	90 parts
Formalin (40 per cent. solution formaldehyde) - - -	7 ,,
Glacial acetic acid - - -	3 ,,

Another good fixative for insects is Carls' Fixative, made as follows:—

Absolute alcohol - - - -	15 parts
Formalin (40 per cent. solution formaldehyde) - - -	6 ,,
Glacial acetic acid - - -	2 ,,
Distilled water - - - -	30 ,,

This is considerably stronger than Blés solution, and the insects should not be left in it for more than 24 hours, after which they must be transferred to 70 per cent. alcohol for storage.

Special methods of collecting:—Besides the general work with net and beating-stick in the field, there are many special methods of collecting which need to be made use of for the capture of certain kinds of insects. The chief of these are mentioned here:

(1) *Flower-blossoms*:—In Australia the blossoms of Tea-tree (*Leptospermum*), *Angophora*, Eucalypts and Wattles (*Acacia*) are visited by a large number of insects, particularly Buprestid and Cetoniine beetles and Thynnid wasps; the best months for this blossom-collecting are September around Brisbane, November around Sydney, and January in the higher and colder localities. In New Zealand the best blossom-collecting is done at Manuka-blossom (*Leptospermum scoparium*), but there is not the same variety of flower-haunting insects as in Australia.

(2) *Bark*:—Both the dry, peeling bark of many kinds of Eucalypts and the moist, clinging bark of many forest-trees yield good hauls of beetles and other insects. The former is easily peeled off; for the latter, a broad-bladed cold-chisel is useful. Good catches of rare insects and their larvae can often be taken under the bark of

rough-barked Eucalypts around gum-flows. In New Zealand, the bark of the large native Conifers, either standing or fallen, is often productive.

(3) *Logs, rocks and stones*:—Turning over fallen logs, flat rocks and stones often results in good catches in both countries. In Australia, this often discloses ants' nests, which are a special study in themselves (see below).

(4) *Examination of the forest-floor and its débris.* Many small beetles and other insects are confined to the floor of the primitive forest. The débris may either be gathered up and scattered about on a white sheet or piece of paper, the insects being caught as they try to escape, or a quantity of débris may be brought home in a sack and examined at leisure. There are various devices for inducing the insects to leave the débris without the necessity for a long examination; e.g. placing it in a large funnel with its stem dipping into a glass-tube or bottle in a dark box, in which case the insects, being positively geotropic (i.e. attracted towards the earth), find their way down the funnel, and finally fall into the bottle.

(5) *Inquilines*:—The nests of ants and termites harbour a number of rare Beetles, Hemiptera, etc., known as *inquilines* (p. 184) which can only be found by very careful examination of these nests. Some of them rely upon protective devices for concealment, and must be searched for until found; others attempt to escape by speed, and are best captured by having a number of small tubes filled with 70 per cent. alcohol in one's pocket and emptying one of these over the fleeing insect, which may then be carefully picked up with forceps or camel's-hair brush.

(6) *Traps, Baits etc.*:—These can be used when collecting is being carried on in the same locality over a period of some weeks. One of the best baits is a compact pile of freshly cut vegetation placed in a fairly damp situation; if visited at intervals, a definite sequence of insects can be obtained from it, including fungus-feeding forms when the mass has sufficiently decayed to allow of fungi appearing in it.

Tins may be sunk into the ground with their tops level with the surface in suitable country; numbers of ground-haunting beetles and other insects will tumble in, especially if the tins are baited with a piece of meat. A pile of dung may be used as a trap for many beetles. Dead birds or small mammals, half-buried in the ground, attract many insects.

Cutting the trunks of trees so as to produce a flow of sap is useful in certain cases, e.g. in Eucalypts, to produce a gum-flow, or in native figs, which exude a sweet, milky secretion. The great longicorns of the genus *Batocera* can be taken by visiting flows of this milky secretion after dark.

(7) *Night-collecting with a lamp*:—A good acetylene lamp of the kind used on bicycles is a valuable aid to collecting; not only does it attract numerous insects after dark, but it is useful for examining tree-trunks, palings, foliage etc., on which many nocturnal species may be found. On warm, still nights, a white sheet hung up in a suitable locality, with a lamp shining upon it, will prove a happy hunting ground. A net should always be carried with the lamp, as most insects are only attracted for a moment and are often difficult to secure.

(8) *Sugaring*:—This method, so successfully used in England, does not yield good results in Australia. In New Zealand, however,

it is one of the best methods of night collecting, the most profitable localities being along the edge of the native forest, or plantations of introduced trees such as *Pinus radiata*. To make the sugaring mixture, take a pint of black treacle and stir into it as much beer as will give the mixture the consistency required for easy application to the tree-trunks with a brush. Just before use, stir into the mixture a table-spoonful of rum. Apply in vertical streaks about two inches wide and two feet long, at a height of three to five feet above the ground. Both rough-barked and smooth-barked trees give good results in New Zealand. Some skill is required in bottling or pill-boxing the moths and other insects without damaging them or messing the receptacle.

The Collection.

Having completed the field-work for the day, the next problem to be faced is what to do with the captured insects. When insects are killed in the cyanide bottle, they undergo *rigor mortis* for periods from 10 to 36 hours, and it is advisable not to attempt to set them at once, but to leave them in the bottle until they are sufficiently relaxed to enable setting to be done. The only exception to this rule is that of very small, delicate species, which should be brought home alive, placed in the killing-bottle only just long enough to expire, and then taken out and set immediately.

Pins:—There are two types of entomological pins in use (a) British, either white (silvered or nickelled) or black (japanned or enamelled), of varying sizes and thicknesses, the largest being No. 1 of Messrs. Kirby and Beard, 33 mm. long, the smallest No. 20, 14 mm. long; (b) Continental or American steel pins, all of the same length, (about 37 mm.), but of varying thicknesses, and with larger heads than the British. Both have disadvantages; in the British type, the smaller sizes do not raise the specimens sufficiently above the floor of the box, and often bend when inserted into cork or lino; also, the points of the smaller sizes of pin are liable to turn; in the Continental type, the great height of the pin requires store-boxes either corked on one side only, or else inordinately wide to prevent the heads of the pins clashing; the large heads are ugly and of little use, since the pins can only be safely held in the forceps down near the point, and are liable to buckle and also to vibrate unless handled carefully.

The best plan seems to be to use only the stronger kinds of pins, preferably Nos. 1, 3, 5 and perhaps 8 of the British make. Insects which are too small to be pinned on these should be double-mounted by one of the methods given below.

In pinning a specimen, the pin should be inserted through the middle of the mesothorax, and driven through until the insect is about two-thirds of the way up the pin; the pin should not slant backwards, but should be placed either vertically or a little inclined forwards. For Coleoptera, insert the pin through the anterior part of the *right* elytron, and bring the point through between middle and hind legs.

For very minute insects, a special *silver-wire pin* of very small size can be obtained in packets from Messrs. Cherry and Co., Gisborne, Victoria; or, failing these, the slender needles of Prickly Pear make very good substitutes. To pin a minute insect successfully, lay it out, immediately it is killed, on a sheet of white paper, and insert the point of the pin correctly, with the aid of a pocket-lens, just sufficiently far in to enable the insect to be lifted up on it. Then take a clean handker-

chief and press the pin home through the insect resting lightly against the handkerchief, until it has penetrated to the required depth.

Certain insects, especially plant-sucking types such as Hemiptera, have a body-fluid which causes rapid erosion of the ordinary white pins; these should be set on black pins or else mounted in some other manner.

Double-mounting:—Several methods of double-mounting for small or medium insects are generally practised. They all agree in that the insect is carried on a special mount which in its turn is carried on a large pin which also takes the labels. A good plan is to use only one type of large pin, either No. 1, 2, or 3 of the British make, for all double-mounts, so that all the insects can be arranged at the same height above the ground and have a uniform appearance.

In all double-mounting, in the case of the ordinary right-handed worker, it is advisable to have the large pin at the right of the mount, so as to avoid the chance of damage to the specimen from the sleeve or forceps.

The following methods of double-mounting are the best:—

(a) *With Polyporus pith*:—This pith is sold in narrow strips. It is so soft that the smallest pin or Prickly Pear needle will penetrate it with ease. The pith should be cut into short strips about 10-12 mm. long, and the large pin should be inserted into each strip to about one-third from the head. The insect, when set, is pinned into the free end of the pith, and the labels are placed on the large pin.

(b) *With celluloid*:—Instead of pith, the celluloid of the ordinary flat photographic film may be used, cut into narrow rectangular strips; these are very neat, being almost invisible, but care must be taken in inserting the small pin into them, as the medium is not so soft as the pith.

The use of celluloid or white card for mounting small insects by means of gum is dealt with lower down (p. 494).

(c) *Elbow-pin mounts*.—For this excellent method, the black enamelled pins No. 000 made by Winkler and Wagner, Halzingergasse, Vienna, must be used, together with either a No. 1 British or No. 7 Continental pin. Taking the No. 000 pin, first of all bend the last ¼ inch or so at right angles to the rest (fig. ZB3, A), using a small rectangular block of wood for the purpose. In this block, which should be somewhat shorter than the stout pin itself, a narrow groove should be cut in which the pin may be held rigid by pressing with the thumb of the left hand; holding it thus, with the point upwards and projecting above the block (ZB3, B), take the slender pin and place as shown in fig. ZB3, C, with the bent end pointing downwards on opposite side of the block to the stout pin, and the rest of it at right angles to the latter and projecting well beyond it; hold it in position by first finger of left hand, keeping block firm; then twist the thin pin four or five times round the stout pin and cut off protruding head-portion of thin pin. Release pins from block, turn stout pin point downwards, and slide spiral portion of thin pin right up to head of thick pin. The spiral having been coiled on the tapering end of the stout pin, it will be found to hold tightly when forced up on to the uniformly thickened upper part of that pin. The insect itself is pinned by inserting the point of the slender pin into it, preferably from the side (fig. ZB3, D); finally, slide the spiral back into convenient position

›ut one-third from head of stout pin, with insect to left, and label.

The great advantages of this method are that, the point of the all pin being upwards, the insect can be pinned from the side so that · *point only just projects through the thorax, and a microscopical* *amination of the specimen can be made dorsally, ventrally and from*

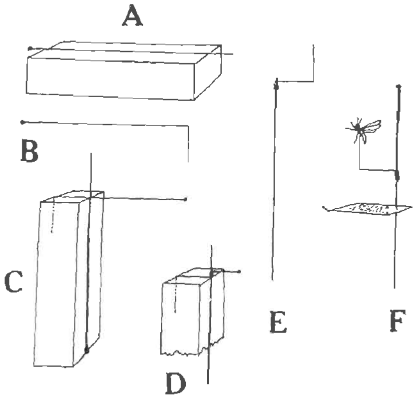

Fig. ZB3. Method of making elbow-pin mounts with stout pin (No. 7 Continental) and slender pin (No. 000); A, slender pin laid on wooden block ready for bending; B, slender pin bent; C, block upended with stout pin in groove and bent slender pin placed in position for winding; D, slender pin spirally wound round stout pin (projecting head not yet cut off); E, slender pin with head cut off, spirally wound and pushed up to top of stout pin (position for use when pinning insect); F, *small insect pinned and labelled in final position.*
R. J. T. del.

one side, without any interference from the shaft of the pin. It is also a very neat method in appearance, and the specimens take up very little room.

Setting:—Only flat boards should be used, and the groove should be deep enough to allow of the insect being set well up on the pin (*two-thirds from point*). *For expeditions, setting-cases in the form of store-boxes carrying a series of setting-boards on each side,* held in position by ledges along the two shorter ends of the box, are very useful. For Australia, two such cases may be needed, one containing larger boards only, from 3 to 5 inches in width or more, the other containing smaller boards, from 2½ inches down to ½ inch in width; *for New Zealand, only one case containing the smaller boards will usually be required.*

Light, serviceable setting-boards can be very quickly made from the pith of the flower-stalk of the aloe; the groove should be cut out straight and deep with a pen-knife, and the whole board covered with white paper. Such boards can be pinned inside a store-box, as they are easily pierced with large pins.

For setting minute insects, good boards can be made by slicing

ordinary corks down the middle, cutting away the convex outer portions until each half is 8 to 10 mm. high, and then cutting a fine groove in each with a penknife; these corks can then be pinned firmly into small collecting boxes, and used for setting minute insects on silver-wire pins or Prickly Pear needles; this is an excellent method for small Tineoidea, Hydroptilid caddis-flies, Coniopterygidae, Psyllidae, Aleurodidae, Copeognatha etc.

For the actual operation of setting, the pinned insect should be placed exactly in the centre of the groove, with the pin inclined very slightly forward and the bases of the wings just level with the surface of the board. For large insects, the spreading of the wings is best done by means of a piece of cotton attached to a strong pin; this pin

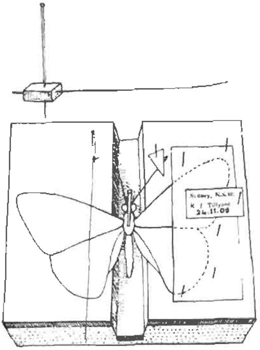

FIG. ZB4. Setting a butterfly on a flat board. On the left side, the wings are shewn being spread with the aid of a length of cotton attached to a pin; on the right side, the wings are in their correct position, with paper slip covering them and fixed with five cabinet points, and the label is pinned alongside the insect. Above, a typical setting-bristle, for use with smaller insects. [*R. J. T. del.*

is inserted in front of the point to which the forewing will reach when pressed out, and the cotton is then drawn between the two pairs of wings and gently pulled until one pair is pressed down on to the board. With the aid of a needle or strong pin, the wings are then arranged in the required position, the cotton being held tightly by one hand while the paper slip is placed in position and pinned down by the aid of the forceps in the other. *Cabinet points* (i.e. the points of entomological pins, cut off about 6 mm. along the pin) are sold in boxes for the purposes of setting and labelling, and are better for this purpose than small pins, which project too far and also tend to buckle.

Position of wings:—A good rule to follow in setting is to arrange the forewing so that its posterior margin is at right angles to the body-axis of the insect, the hindwing being arranged suitably below it in a natural position. This position is shown on the right side of fig. ZB4.

Setting-bristles:—For medium to small insects, a setting-bristle

may be used instead of a piece of cotton. Several sizes of such bristles should be kept on hand, made from pig's bristles or stiff horsehair. To make them, cut a small, rectangular piece of stiff cork or lino, about 7 mm. by 5, pierce it lengthwise by a pin, withdraw pin and insert into the hole a bristle of the requisite length, the thinner end being free. Then transfix the cork, with bristle inserted, by means of a strong pin, so that it projects just far enough below to give a good grip of the setting-board. In using these bristles, the pin and cork are fixed *below* the insect to be set, and the bristle presses down upon the wings and keeps them opened while they are drawn up into the required position.

Mounting on card with gum medium:—A good gum for this purpose can be made as follows:—

Gum Arabic	- 60	parts
Sugar	- 30	,,
Carbolic Acid	- 2	,,
Alcohol (95 per cent.)	- 8	,,
Water	- 45	,,

The sugar prevents the gum from becoming brittle on the card in hot, dry weather, and the carbolic acid prevents the formation of mould, etc.

Small Coleoptera and Ants are usually mounted on card by spreading a fine layer of the gum on it and then arranging the specimen with legs outspread, so that the tarsal segments, etc., can be easily examined. But, as many of the characters used in classification cannot be seen in dorsal view, it is wise to mount some Coleoptera on their backs, and some of the ants on their sides.

Small Hymenoptera, Hemiptera etc. are usually mounted at the apices of narrow, triangular slips of white card fixed on large pins at about two-thirds up from the point. A tiny droplet of gum only should be placed at the apex of the card by means of the point of a needle, and the insect is best mounted by being arranged in position on the edge of a cork or some other raised surface, and then bringing the gummed tip down upon it lightly so as to pick it up without compression. Place card to left of pin, with head of insect facing forwards. The best position for the insect is lying upon one side, so that all the characters can be examined dorsally, ventrally or from the free side.

Bristling:—In the case of Dragonflies and some long-bodied Lacewings, it is necessary to bristle the abdomen before setting, to prevent it breaking off when dry. To do this, a set of pig's bristles should be kept for the larger species, horse-hair cut into lengths for the smaller. The bristle should be pointed by cutting the thicker end slantwise with a pair of scissors; this end should then be inserted between and just in front of the middle legs, and run carefully down to within a short distance of the terminal abdominal appendages. Cut off bristle close to legs with a pair of fine dissecting scissors; then pin and set specimen in the usual manner. Care should be taken not to disarrange the appendages.

Relaxing:—To relax set or stiffened insects, place a layer of clean sand at bottom of a large glass jar and saturate it with a dilute solution of carbolic acid and water. The use of a little powdered thymol is also recommended and the sand used must be changed every two

months. Support the insects in such a way that they do not come into contact with the sand, and cover the jar tightly. This method gives perfect relaxation, but bright colours are liable to become dulled.

For quick relaxing, place insects in water vapour atmosphere at about 40° C.; they will relax in about an hour without wetting their wings. Relaxed insects are liable to mould unless carefully dried before being stored away.

Labelling:—Every specimen should bear a label on the pin, containing the following information:—

> Locality of capture, with altitude where this is of importance.
> Date of capture.
> Collector's name.

In the case of reared specimens, an additional label should be given "Reared from larva" or "Reared from pupa." In the case of parasites, the name of the host should be given on a separate label. Where the insect is phytophagous, and the food-plant is of importance, this also should be given on a label. If a pair of insects are taken *in copula*, this fact should be noted on each label of the pair. When specimens are received by gift or exchange from any well-known collection, a separate label "Ex coll. . . . ." is often added. All labels should be neatly printed or written and of the smallest size compatible with legibility; a good working size is about 10 mm. by 5 mm. Labels should be placed face upwards, and sufficiently far below the specimen to be read with ease; *only in the case of Lepidoptera is it advisable* to place them face downwards.

Storing the Collection:—The ambition of every collector is to have a well-made *cabinet* in which to exhibit his specimens. Good cabinets are made by Messrs. Cherry and Co., Gisborne, Victoria, and also by Mr. O. S. Pennicuik, 58, Salisbury Road, Christchurch, N.Z. The cost of a twenty-drawer cabinet in mahogany is about £28, the size of each drawer being 17 x 17 x 2¼ inches. Cabinets, however, being beyond the purse of most collectors, something much cheaper and equally satisfactory has to be provided; such receptacles are *store-boxes* and *cartons*.

Store-boxes are made of wood in various sizes, two of the most useful being 17 x 12 inches and 14 x 10 inches. Smaller sizes are made as pocket or postal boxes. It is advisable to have them made a full 3½ inches deep, inside measurement, but the ordinary type of box is not so deep as this, and there is danger of large pins on either side overlapping. Good store-boxes of this type are made by Messrs. Cherry and Co., Gisborne, Victoria, and also by Mr. A. D. Donn, 59, Victoria Street, Christchurch, N.Z., the price of the large size being 15/-. Each storebox is lined with cork or lino on both sides.

Cartons are a special type of box made of very stout cardboard neatly papered outside, and having a close-fitting glass lid; they are only lined with cork on the one side, and are just under 2½ inches in depth. Excellent cartons are made by the firm Les Fils d'Emile Deyrolle, 46, Rue du Bac, Paris; at the present rate of exchange, these can be imported into Australia or New Zealand at a cost of about 7/6 each for the large size, which is about 15 x 10 inches inside measurement. These cartons are absolutely airtight, and are preferable to store-boxes for all small or delicate specimens, as the insects can be examined through the glass without opening them; in fact, each carton

is a separate cabinet drawer, and they can be arranged in tiers so as to take up considerably less space than store-boxes.
with naphthalene before specimens are placed in it. If moth-balls are used, as in ordinary store-boxes and cartons, they may be fixed in position by heating a large pin to dull red heat and then forcing it through the centre of the moth-ball. In cabinet-drawers, narrow spaces are provided round the edges, in which finely powdered naphthalene should be placed.

Duplicates of many insects can be conveniently stored in paper-triangles (p. 486) arranged according to sizes in ordinary tobacco boxes; each specimen should have its label placed either inside its triangle with it, or else written on the flap of the triangle. A liberal sprinkling of naphthalene should be given inside the box, and it should be carefully sealed up and put away.

Pests of stored insects:—The insect collection is subject to the attacks of various pests, the chief of which are *Anthrenus*, cabinet-mites (Copeognatha), mould and grease.

The species of *Anthrenus*, or Museum-beetles, are easily the worst pests in Australia, though seldom met with in New Zealand. Their larvae bore into the bodies of dried insects, and eat the inside completely out, leaving a mere shell hanging on the pin. Naphthalene is of no avail against this pest. The best remedy is a careful, periodical examination of all store-boxes and cabinets, with a quarterly fumigation by means of carbon bisulphide. The ravages of *Anthrenus* are noticeable through the pile of dust and débris which collects beneath the insect attacked. All affected insects should be immediately removed and placed in a quarantine box or chamber, in which a small open jar of carbon bisulphide should be placed, the lid of the box being securely closed and left shut for twenty-four hours. It is advisable to fumigate each store-box or drawer separately also; this can be done either by removing bodily to the quarantine chamber (if large enough), or by placing a watch-glass or crystal dish in one corner and pouring into it some carbon bisulphide.

Cabinet-mites are small, wingless insects of the Order Copeognatha. Three species are common in Australia and New Zealand, viz. *Atropos pulsatoria* Müll., *Lepinotus inquilinus* Heyd. and *Troctes divinatorius* L. They are very active, and devour hairs, scales and the more delicate parts of the integument. In the case of small and delicate specimens, they can work as much havoc as *Anthrenus* does to a large one. They are more or less checked by naphthalene, but soon become active when the odour becomes weak through non-renewal.

A good reagent for use inside store-boxes can be made by melting together equal parts of naphthalene and carbolic acid and crystallising out quickly in cold water; this mixture is a splendid protection against *Anthrenus*, cabinet-mites and mould, but has the demerit of discolouring and becoming moist, so that it is apt to stain the boxes. It can be fixed in a corner by wrapping a lump in cotton-wool and placing same inside a small pill-box, which must be firmly fixed in position with pins.

Mould attacks insects chiefly in warm climates where alternations of dry and moist atmosphere are prevalent; it is especially bad in Brisbane and Sydney, very rarely met with in New Zealand. Any insect attacked with mould should be at once removed to a special box, cleaned carefully with an alcoholic solution of mercuric chloride, and then,

quarantined for a considerable time in a box well supplied with the naphthalene-carbolic acid mixture. When once mould obtains access to a collection it is most difficult to eradicate; continuous watchfulness and regular fumigations are required to keep it from spreading rapidly.

Grease is an internal trouble due to the liquefaction of the fatty contents of the bodies of certain insects, chiefly those Lepidoptera and Coleoptera whose larvae bore into wood, and certain large Orthoptera and Odonata. A greasy insect is not only unsightly, but is liable to stain the store-box permanently. Benzene, chloroform and ether will all dissolve grease, but a better reagent is powdered magnesia; the specimen should be immersed in benzene and then in powdered magnesia for a considerable time, until all the grease has been absorbed by it, when it can be taken out and the powder either blown off it or lightly brushed away. But the best plan is to learn which insects are liable to develop grease, and make provision for treating them when freshly killed. The fresh specimen should be placed on its back on cotton-wool, the abdomen opened from base to near apex with a pair of dissecting scissors, and the fatty contents cleaned out. A swab of cotton-wool plunged into powdered magnesia should then be used to give a final cleaning, after which the empty cavity should be liberally treated with the powder; finally, a plug of cotton wool should be made of such a size that, when carefully inserted into the body-cavity, the natural shape of the latter is preserved; the cut sides of the abdomen should then be drawn down over the plug of cotton wool, and the insect set in the usual manner, with pins to preserve the shape of the abdomen while drying.

Dry preparations of larvae and soft-bodied insects:—The old method of eviscerating larvae and then drying them by heating over a Bunsen flame is not recommended, as the distal end of the abdomen is destroyed and with it nearly always some characters of value. Good dried preparations of larvae can be made as follows:—

Fix the specimens alive in Blés solution, laying the tubes on their sides so that the insects die extended. In the case of certain larvae covered with a waxy film, into which the fixative will not penetrate, immersion for a short time in chloroform is usually sufficient to remove the film. Leave in the fixative until thoroughly hardened (several weeks for medium to large specimens); then dehydrate in absolute alcohol for one to three days. Make a few incisions here and there in the cuticle with the sharp point of a knife or scalpel, and transfer specimen to xylol or chloroform. When the specimen is thoroughly cleared, remove from the liquid and allow to dry on a piece of filter-paper. The tissues being hardened, the specimen will not collapse, and can be mounted in any suitable way required; in the case of green larvae, the colour will have been lost. For larvae which are semi-transparent in life, the natural appearance can be attained by passing the specimen from chloroform into a solution of paraffin-wax in the same liquid at about 40° C. for some hours; then rinse sufficiently in chloroform to remove the film of wax on the cuticle, and dry as before. As considerable amounts of absolute alcohol are required in these processes, it is best prepared by heating crystals of copper sulphate until the anhydrous form is obtained, and then shaking this up in a jar of strong spirit and allowing to settle; the anhydrous copper sulphate will extract all the water from the alcohol, and the decanted remainder will

be near enough to absolute for this purpose; the same alcohol can be dehydrated and used again and again.

Storing specimens in alcohol:—A collection of specimens in 70 per cent. alcohol is an important part of any complete entomological collection, and must be systematically provided for. For ordinary specimens, a number of each species may be placed in separate glass tubes, well-corked, with labels written in indelible black ink inside the tubes, and the corks thoroughly coated with melted paraffin-wax. These tubes can be conveniently stored in half-pound tins such as are used in jam- or sweet-factories; a label outside each tin should state the Order and family represented, and the tins should be arranged on shelves so that all the labels are visible.

For minute and valuable specimens, including dissections, specimens prepared for sectioning etc., small tubes should be used with stoppers made of elderberry pith; ordinary corks contain a colouring matter which is gradually dissolved by alcohol and discolours the specimens, even damaging the more delicate tissues in some cases. These tubes should be placed on cotton wool in the new 1-lb. Mason jars fitted with rubber ring, glass lid and screw top which screws tightly down upon lid and rubber, the jar and tubes, of course, having been filled with 70 per cent. alcohol before closing. These jars do not require a coating of paraffin-wax, and will retain the alcohol indefinitely. The tubes should be supplied with small labels in indelible ink and also larger index numbers entered in a note-book, so that the number of any specimen required can be referred to and the tube extracted with the minimum of trouble.

Methods of Study.

For rapid examination of specimens a good pocket-lens is most useful; preference should be given to one with a wide field, as the continuous use of lenses with narrow fields of vision is not good for the eyes.

For systematic study and descriptive work, a good binocular microscope is essential; this should be provided with two pairs of eye-pieces and three pairs of oculars, giving a range from very low to medium magnifications. It should also be capable of carrying a camera-lucida for drawing purposes. In those binoculars in which the diameter of the tube is large, a special carrier may have to be devised for the camera-lucida.

Dissections:—These are best made under water or isotonic salt solution in a small, fairly deep, developing dish coated with a good layer of paraffin wax. The ordinary single-lens dissecting microscope can be used with such a dish for dissection of medium to large insects. In the case of minute dissections, these are best carried out either in cedar oil or glycerine under the binocular microscope. The most useful instruments in the dissection of insects are mounted and well sharpened needles, some of which should have triangular points, fine knives for cutting, straight and curved dissecting scissors with fine points, and a special type of very small dissecting scissors having a spring handle at right angles to the blades.

Microscopic preparations:—For the study of chitinous structures, maceration of the specimen in 10 per cent. solution of caustic potash is necessary; this may be done either by boiling in a small porcelain dish over wire gauze on a tripod (boiling in a test-tube is a bad method,

as the caustic solution is very apt to spurt out suddenly, carrying the specimen with it), or else, in the case of very delicate specimens, by immersion in the cold liquid until the muscles and other non-chitinous parts are destroyed. The macerated specimen should be thoroughly washed in several changes of water before proceeding any further. It may then be examined under the binocular and all unnecessary parts cut away. If of a hard or fairly hard nature, a Canada Balsam mount may be made, as follows:—Transfer specimen to 70 per cent. alcohol, with at least one change; thence through 90 per cent. alcohol to absolute alcohol; thence to clove oil. The time taken in each of these reagents will depend upon the nature of the specimen; for very small objects, a few minutes in each is quite sufficient. Examine the specimen while in clove oil, trim up and arrange on slide; draw off excess of clove oil with slip of blotting-paper and mount at once in Canada Balsam. Label slide.

If the specimen is of a soft nature, it is advisable to use glycerine-jelly for mounting, otherwise there is great danger of shrivelling. The jelly is prepared as follows:—

Clear Gelatine	- - - 10	grammes
Distilled water	- - - 70	,,
Pure Glycerine	- - - 80	,,
Carbolic Acid	- - - 2	,,

Cut up the gelatine small and soak for two hours in cold water. Place the vessel containing it in hot water until gelatine is dissolved. Then add the glycerine and carbolic acid and stir well with a glass rod, keeping the water outside the vessel up to boiling point. Strain through fine muslin and filter hot through glass wool. Store in glass-stoppered bottles. This preparation is solid at ordinary temperatures and must be stood in a vessel of hot water before using. Preparations can be placed directly into the warm medium on the slide from water, but it is advisable to pass them first through a mixture of one-half glycerine and one-half water. Warm the slide before putting the drop of jelly on it. If the jelly sets on the slide before the specimen is properly arranged, it can be warmed by passing slide over a Bunsen flame protected by gauze. Leave mounts to dry for a week or more, then ring with Brunswick Black or Canada Balsam.

Glycerine-jelly mounts of the male genitalia or other parts important in descriptions may be made in the above manner but mounted on small pieces of glass cut from a cover-slip. A good size is 10 x 7 mm.; when the specimen is suitably arranged on this, it should be covered with a second piece of glass about 5 x 5 mm. The under-slide may then be glued to a small strip of celluloid by means of Canada Balsam, and affixed to the pin beneath the specimen from which it was originally dissected. If very clear definition is not required in examining the mount under the microscope, the whole mount may be made with two small slips of celluloid in place of the glass, the pin being inserted direct into the under-piece.

Serial Sections:—Soft internal structures dissected out without any attached chitinous parts may be sectioned in the usual manner known as single-embedding. For whole insects, or parts which contain chitin, the method of double-embedding is advised, with or without the addition of softening in soap-solution, according to the hardness of the specimen to be dissected. Success can only be obtained by

using the greatest care in this method and particularly by using the sharpest possible knife in the microtome. The method may be epitomized as follows:—

1. Pass specimen from 70 per cent. alcohol through 90 per cent. to absolute alcohol; six hours in each.
2. Pass into absolute alcohol plus pure ether (equal parts); 24 hours.
3. Place in covered crystal dish in ½ per cent. solution of celloidin in equal parts of alcohol and ether; 24 hours.
4. Change to 2½ per cent. celloidin solution; 24 hours.
5. Change to 5 per cent. celloidin solution; 24 hours.
6. Harden in chloroform vapour under a bell-jar, until the celloidin block is of the consistency of cheese; 2-3 hours.
7. Shape and trim up block, with object correctly orientated for the sections required; transfer to liquid chloroform for further hardening (½ hour or more).
8. Place hardened block in liquid chloroform with parings of paraffin-wax (58° M.P.) on top of bath at about 40° C. Leave overnight. The chloroform will dissolve the wax and does not wholly evaporate.
9. Remove to melted paraffin-wax (58° M.P. in warm weather, 52° M.P. in cold weather) within bath; 2-3 hours.
10. Embed block in paraffin-wax and section in the usual way.
11. Double-stain either with Ehrlich's Haematoxylin and Eosin, or with Heidenhain's Iron Haematoxylin and Orange G. Mount with Canada Balsam.

If special softening is required, place specimen in a solution of soft soap in 70 per cent. alcohol; leave for 24 hours or longer, as required, and wash thoroughly in 70 per cent. alcohol before beginning process 1. Specimens treated in this way will have the contents of all fat cells removed, but are otherwise unaltered by the soap solution.

A somewhat quicker modification of the above method may be made by substituting the following process for 2-7 inclusive above:—Pass direct from absolute alcohol into clove-oil-celloidin, leaving object to infiltrate for at least three times as long as it takes to clear. Remove to chloroform, together with sufficient celloidin to form a thick coating. Harden for 2 hours in chloroform, then pass to process 8 as given above. Good results can be obtained by this method, but the longer method is less liable to cause distortion of tissues.

Tracheal Studies:—The study of the wing-venation of Insects is now recognized as of the greatest importance, and the only way in which a student can fully comprehend the homologies of the veins is by studying the precedent tracheae in the larval or pupal wing-sheath. Careful dissection of the parts under water should be made in the usual manner, and the wing-sheath should be transferred at once to a slide with sufficient water to keep it thoroughly moist. A demonstration of the homologies should be given at once under the microscope; if a permanent record is desired, camera-lucida drawings or photomicrographs should be made There is no way in which the air can be retained in the tracheae permanently, but the wing-sheaths may be mounted in warm glycerine-jelly, when the air will be retained for a considerable time. When the air passes out, the tracheae become practically invisible.

APPENDIX I

GLOSSARY

This Glossary contains definitions of all the scientific and technical terms used in this book, with the exception of those which only occur once and are defined or explained in the text; these latter can be found by referring to the Index. Where considered necessary, the derivation of the term is given in brackets.

Acetabulum (Lat.=a small cup, and thence the hip-socket), the coxal cavity or cavity into which the coxa is inserted.

Acinose (Lat., *acinus*, berry), shaped like a bunch of grapes.

Aculea (Lat.), a minute, needle-like spicule (on wings of some Lepidoptera, see p. 399).

Aculeate (Lat., *aculeus*, a sting), furnished with a sting; used of the sting-bearing Hymenoptera.

Aedeagus, the external male genital organs, i.e. penis and accessory structures.

After-body, in Coleoptera, all the body behind the pronotum.

Alitrunk, in Hymenoptera, the thorax plus the attached first abdominal segment.

Allotype, see *Types*.

Alula (Lat. = a little wing), a small membranous lobe attached to base of forewing in Diptera and some Coleoptera.

Ambient vein, a vein partially encircling a wing close to the margin (see Hemiptera, fig. Q19).

Amphipneustic (Gr. *amphi*, on both sides; *pneusis*, breathing), having spiracles at fore and hind ends of the body only.

Anal fan, a fan-like extension of the anal area of the hindwing.

Anal veins, the three posterior veins of the insect wing (first, second and third anals).

Anus (Lat.) or **anal opening**, the posterior opening of the alimentary canal.

Anastomosis (Gr. = an outlet), the junctioning or partial fusion of one vein with another (term used chiefly by Lepidopterists).

Ante-alar, situated in front of the wings.

Anteclypeus, see *clypeus*.

Antenna (Lat.=a yard-arm), the usually long, slender sense-organs of which a pair are carried on the heads of all insects except Protura.

Antenodal, a cross-vein situated between C, Sc and R between base and nodus (see Odonata, p. 69).

Apertum (Lat. = open), a special cell, open basally, in the hindwing of Coleoptera (see p. 180).

Apneustic (Gr. *a*-, not; *pneusis*, breathing), not provided with spiracles.

Apodeme (Gr. *apo*, off, from, and *demas*, body, frame), a ridge or ingrowth of the cuticle, serving for the attachment of muscles.

Appendix dorsalis or **median tail-filament**, a slender segmented filament attached to the supra-anal plate.

Apterous (Gr. *a*-, not; *pteron*, wing), wingless; in Coleoptera, used also of species which possess elytra but no hind wings.

Archaic (Gr. *archaikos*, ancient), see under *generalized*.

Archetype (Gr. *archetupos*, original), the original (usually hypothetical) type or form from which a whole group of existing forms is supposed to have sprung.

Arculus (Lat.=a little bow or arch), a special vein-formation in Odonata, see p. 69, and Diptera, see p. 338.

Areocel, in Lepidoptera, the closed cell formed by fusion of the areole with the basal cell (see p. 401).

Areole, in Lepidoptera, the closed radial cell of the forewing.

Arolium in Orthoptera, the small pad between the tarsal claws (see *empodium*).

Arista (Lat.=ear or beard of corn), the terminal, hair-like portion of the antennae in the higher Diptera (see p. 334).

Asymmetry (Gr. *a-*, not; *summetria*, correspondence), lack or absence of symmetry.

Auricle (Lat. =a little ear), a small, ear-like process on sides of second abdominal segment in Odonata (see p. 71).

Autochthonous (Gr. *autochthon*, aboriginal), used of species which are considered to have arisen as part of the native or aboriginal fauna or flora, as contrasted with those which are considered to have immigrated from regions outside.

Axillary (Lat., dimin. of *axis*), a small thoracic sclerite with which the swollen base of the wing articulates.

Basipodite, see *podite*.

Brachypterous (Gr. *brachus*, short; *pteron*, wing), with abbreviated wings.

Callus (Lat. = hard skin), a hard lump or swelling of the cuticle, in particular, such a swelling at the base of a wing, articulating with the thorax by means of the axillary.

Campodeiform (from *Campodea*, a genus of Thysanura), a term applied to insect larvae which are active and shaped like *Campodea*, with well-developed legs.

Cardo (Lat. = a hinge), the basal piece or coxopodite of the first maxilla.

Carina (Lat. = a keel), a raised ridge of the exoskeleton.

Caudal (Lat. *caudalis*) belonging to the tail; *caudal setae*, the tail filaments, i.e. cerci and appendix dorsalis.

Cell (1), in biology, a minute portion of protoplasm containing a nucleus; (2) a closed area in the insect's wing, consisting of membrane surrounded by veins.

Cephalothorax (Gr. *kephale*, head, and *thorax*), the head and thorax fused together without any clearly marked division between them.

Cerci (Gr.=tails), the appendages of the tenth abdominal segment, usually slender, filamentous and segmented.

Chaetotaxy (Gr. *chaite*, bristle; *taxis*, arrangement), the arrangement of the setae or bristles on any portion of the exoskeleton.

Chitin (Gr. *chiton*, a tunic), the transparent, horn-like substance which forms the cuticle of insects.

Chorda (Gr.=gut, string of harp, etc.), the portion of vein R_{4+5} separating the areole from the basal cell in Lepidoptera (see p. 401).

Chorion (Gr.=leather, skin), the outer covering of the insect egg; *chorionin*, the chemical substance of which this covering is composed.

Chrysalis (Gr. from *chrusos*, gold), the *pupa obtecta* of Lepidoptera.

Clathrate (Lat. = trellised), covered with a raised trellis-work.

Clavate (Lat. *clava*, club), clubbed, or having a swollen or knobbed apex.

Clavus (Lat.=nail), the sharply pointed anal area of the forewing in Hemiptera and other Orders of Insects.

Cloaca (Lat. = a sewer or drain), the common chamber into which the anus and gonopore sometimes open (very rare in Insects).

Clypeus (Lat.=shield), the sclerite of the head to which the labrum is attached; if divided into two, the piece next the labrum (anterior) is called the *anteclypeus* or *clypeolus*, the piece next the frons (posterior) the *postclypeus*.

Concave and **convex veins**, see p. 22.

Condyle (Gr. *kondulos*, a knuckle), a swollen or rounded end (in Insects, of the mandible only) which fits into a socket.

Convergence, the term applied to indicate resemblance between two forms (either of animals or structures) derived from widely different ancestries, the resemblance having been brought about either by adoption of similar habits, or through reduction or elimination of original differences.

Coriaceous, leathery, toughened.

Corium (Lat. = hide, leather), the toughened basal portion of the forewing of Hemiptera.

Cornicle (Lat. *corniculum*, a little horn), a small, horn-like latero-dorsal process on the abdomen of Aphididae (see p. 171).

Costa (Lat. = side or rib), (1) in venation, the anterior margin of the wing, (2) in Coleoptera, a raised longitudinal ridge on the elytron.

Coxa (Lat. = hip), the basal segment of the thoracic leg.

Coxite, the basal segment of any leg-like appendage, e.g. those of the abdominal sternites.

Crochets, the minute curved hooks on the abdominal legs of Lepidopterous larvae.

Ctenidia (Gr.=little combs), sets of short, stiff setae arranged in rows, like the teeth of combs, as on the head and thorax of Fleas.

Cubitus (Lat. = elbow), the fifth main vein of the insect wing, situated below the media.

Cuneus (Lat. =wedge), a small, hardened, wedge-like area found on the membrane of the hemielytron of certain Hemiptera.

Cuticle (Lat. *cuticula*, the skin), the outer covering of an insect, formed of a non-cellular layer of chitin, secreted by the hypoderm cells.

Cultriform (Lat.), knife-shaped.

Dichoptic (Gr. *dicha*, apart; *optikos*, relating to sight), having the eyes separated.

Dichotomy (Gr. *dichotomein*, to cut in two), a branching of a single stem into two equal and diverging branches (used in phylogeny, of ancestral lines of descent, and in venation, of main veins or their branches). *Dichotomic Key* or *Table*, a Key by which species or higher groups are separated by contrasted characters arranged in couplets (e.g. the Keys in this book).

Dimorphism, sexual (Gr. *dimorphos*, of double form), difference in the form or structure in the two sexes of a species, apart from the actual genitalia.

Disco-cellulars, the collective term applied to all the short, more or less transverse veins closing the basal cell of the Lepidopterous wing distally.

Discoidal cell, a term applied to some outstanding closed cell of an insect wing, e.g. the quadrilateral in Dragonflies or the median cell of Diptera.

Distal, at the far end (opposite of *basal*); *distad*, adverb of direction, towards the distal end; *distalia*, the collective term for all the segments of the antenna except the scape and pedicel.

Dorsum (Lat. = the back), (1) the upper or dorsal surface, (2) the posterior border of the wing in Lepidoptera.

Ductus ejaculatorius, the common duct formed by union of the two vasa deferentia of the male, and opening at the end of the penis.

Ecdysis (Gr. *ekduo*, to strip off), the periodical casting of the larval skin.

Ectoderm, see *Germinal Layers*.

Elytron (Gr. = a sheath), the hardened, convex forewing in the Coleoptera, which acts as a sheath or cover for the hindwing.

Embolium (Gr.=something interposed), the differentiated costal part of the corium in the forewing or hemielytron of some Hemiptera.

Embryo (Gr. *embruon*, the young before birth), the young insect forming within the egg.

Empodium (Gr. *empodion*, an obstacle), a process situated between the two tarsal claws.

Endemic (Gr.=being at home), peculiar to a given region (used of species or higher groups).

Endoderm, see *Germinal Layers*.

Endopodite, see *Podites*.

Endoskeleton (Gr. *endon*, within), the internal skeleton.

Epicranium (Gr. *epi*, upon; *kranion*, skull), the upper portion of the head-capsule in insects.

Epimeron (Gr. *epi*, upon; *meros*, part), the posterior division of a thoracic pleuron.

Epipharynx (Gr. *epi*, upon; *pharunx*, throat), the chitinous surface attached to the inner side of the labrum and bounding the throat from above.

Epiphytic (Gr. *epiphuo*, to grow upon), used of plants growing non-parasitically upon others, e.g. ferns, orchids, etc., upon the branches of trees.

Epipodite, see *Podites*.

Episternum (Gr. *epi*, upon; *sternon*, breast), the anterior division of a thoracic pleuron.

Eruciform (Lat. *eruca*, a caterpillar), shaped like a caterpillar or grub.
Exopodite, see *Podites*.
Exoskeleton (Gr. *exo*, outside of), the external skeleton.
Exuviae (Lat. = the cast skin), the cast skin of the larva at metamorphosis. The word does not exist in the singular.

Facies (Lat.), the external form or appearance.
Fascia (Lat.), a transverse band, e.g. of colour on a wing or other part of an insect.
Femur (Lat. = thigh), the third segment of the thoracic leg.
Fibula (Lat. = a clasp), the small projecting piece at base of posterior margin of forewing in some Lepidoptera and Trichoptera; also called *jugal lobe*.
Filiform (Lat. *filum*, thread), thread-like.
Flagellum (Lat. = whip), the long, slender part of an antenna, omitting the scape and pedicel.
Foramen (Lat. = a hole), a passage or opening in the skeleton; *posterior foramen*, the opening at the back of the head capsule, giving entrance to the thoracic cavity.
Forceps (Lat. = pincers), the pincer-like cerci in Earwigs and Japygidae.
Forcipate, shaped like a pair of forceps.
Fossorial (Lat. *fossor*, a digger), adapted for digging.
Frenulum (Lat. = a little rein), a set of fused or closely contiguous bristles arising from near base of costa of hindwing in some Lepidoptera and used as a link with the forewing in flight.
Frons (Lat. = forehead), the upper anterior portion of the head capsule, usually a distinct sclerite between epicranium and clypeus.
Fulvous (Lat.), tawny, orange-brown.
Funicle (Lat. *funiculus*, a cord), in clubbed antennae, the slender portion preceding the club.
Fuscous (Lat.), dark-coloured, smoky.

Galea (Lat. = helmet), the outer of the two lobes or gnathobases of the first maxilla.
Ganglion (Gr. *ganglion*, a bunching or tumour), a definite swelling in the course of a nerve-cord, caused by an aggregation of nerve-cells.
Gaster (Gr. = belly), in Ants and other Hymenoptera, that part of the abdomen situated behind the pedicel or petiole.
Gena (Lat. = the cheek), the lateral extension of the epicranium below the eye.
Generalized. In biology, the comparative term *generalised* or *archaic* is used in contrast with *specialised* or *caenogenetic* to indicate an ancient or long-standing character as compared with one more newly evolved; *archaic* or *generalized type*, one in which such characters predominate.
Genitalia (Lat.), the sexual organs.
Germinal Layers. In the early development of the embryo, three layers of cells are formed; of these, the outermost is called the *ectoderm*, the middle one the *mesoderm*, and the innermost the *endoderm*.
Gills, organs developed for the purpose of breathing in water; in insects, they may be either external projections of the cuticle, or internal folds of the rectum (as in certain Dragonfly larvae); as they carry tracheae, they are termed *tracheal gills*.
Ginglymus (Gr. *ginglumos*), a ball-and-socket joint.
Glossae (Gr. *glossa*, a tongue), the paired inner lobes or gnathobases of the labium or fused second maxillae.
Gnathobase (Gr. *gnathos*, jaw), a lobe or projecting portion of one of the basal segments of an appendage situated near the mouth, of use in the process of feeding. In the insect maxillae and labium, there are normally two gnathobases, an inner and outer.
Gonads (Gr. *gonos*, begetting), the organs which produce the reproductive cells (sperms or ova).
Gonapophysis (Gr. *gonos*, and *apophusis*, outgrowth), appendages surrounding the gonopore.
Gonocoxite, the basal segment of a gonapophysis.
Gonopore, the genital pore or opening.
Gula (Lat. = throat), the sclerite closing the head capsule below the posterior foramen; also called *gular plate*.

Haemocoele (Gr. *haima*, blood: *koilos*, hollow), a body-cavity formed by secondary enlargement of the blood-spaces.

Halter (Gr.=a dumbbell-shaped balancer held in leaping), the small knobbed organ or balancer which takes the place of the hindwing in Diptera.

Hamuli (Lat.=little hooks), minute hooks developed on the costal margin of the hindwing in Hymenoptera and some Trichoptera and used for connection with the forewing.

Haustellum (Lat., from *haurio*, to draw or suck up), the sucking-tube of the Lepidoptera, formed from the two galeae.

Hemielytron (Gr. *hemi-*, half; and *elytron*), the semi-tegminous forewing of the Hemiptera Heteroptera.

Hexapod (Gr. *hex*, six; *pous*, leg), six-legged.

Histolysis (Gr. *histos*, web, tissue; *luo*, to loose), the decay or breaking-up of the tissues of an animal.

Holoptic (Gr. *holos*, whole; *optikos*, relating to sight), having the eyes conjoined or united in the middle line.

Holotype, see *Types*.

Homology (Gr. *homologein*, to be in accordance with), a correspondence in type of structure between parts or organs of different organisms, due to evolutionary differentiation from the same or a corresponding part or organ of some remote ancestor. In Arthropods, an organ of one segment is said to be *serially homologous* with another of a different segment if the two are derived from corresponding parts.

Hyaline (Gr. *hualinos*, glassy), colourless and transparent, like glass.

Hypandrium (Gr. *hupo*, under; *andrion*, a little man), a projecting plate covering the male genitalia from below (see p. 27).

Hypertrophy (Gr. *huper*, over; *trophe*, nourishment), excessive development or overgrowth of a part.

Hypognathous (Gr. *hupo*, under; *gnathos*, jaw), having the mouth-parts placed below the head.

Hypopharynx (Gr. *hupo*, under; *pharunx*, throat), a tongue-like organ situated within the mouth and forming the lower border of the pharynx (see p. 17).

Hypopleuron (Gr. *hupo*, under; *pleuron*, side), a special portion of the metapleuron in Diptera (see p. 336).

Hypopygium (Gr. *hupo*, under; *puge*, buttocks), the specialized ninth abdominal segment of the male in certain Orders, with its appendages.

Imago (Lat. = a likeness), the adult or perfect insect.

Imbricated (Lat. *imbrex*, a tile), overlapping, like tiles on a roof.

Incisor (Lat.), a sharp tooth, used for cutting.

Inquiline (Lat., *inquilinus*, inhabitant, denizen), the term applied to insects which habitually live as guests or lodgers in the nests of others (chiefly in the nests of ants, wasps, bees and termites).

Instar (Lat. = an image), the stage between two successive ecdyses.

Integument, the outer covering or cuticle.

Invagination (Lat. *in*, and *vagina*, a sheath), the ingrowth or inpushing of a hollow organ from without.

Jugal lobe, see *fibula*.

Jugum (Lat. = yoke), a slender, chitinous process from near the base of the posterior margin of the forewing in certain Lepidoptera, used for linking the hindwing in flight; *jugate*, possessing a jugum.

Labella (Lat. = little lips), the two terminal lobes of the proboscis in Diptera.

Labium (Lat. = lip), the lower lip of insects, formed by fusion of the original pair of second maxillae.

Labrum (Lat.=lip), the upper lip of insects, an unpaired flap attached to the clypeus.

Lacinia (Lat. = lappet or flap), the inner of the two gnathobases of the first maxilla.

Lamella (Lat.=a small plate or blade), a small, flattened, blade-like structure; *lamellate*, provided with lamellae, e.g. antennae of Scarabaeoid beetles.

Lamina (Lat. = a plate or blade), a thin, flat, firm layer.

Larva (Lat.=ghost mask), the term applied in biology to any stage in the life of an animal which differs from the adult or mature form to such an extent that a more or less complicated change, or *metamorphosis*, is necessary to pass from the one to the other.

Larviparous, bringing forth living larvae.

Ligula (Lat. = a little tongue), the piece of the labium in front of the mentum which carries the gnathobases (glossae and paraglossae).

Longicorn (Lat. *longus*, long, and *cornu*, horn), long-horned, i.e. with long antennae; term applied to the beetles of the family Cerambycidae.

Lumen (Lat. = an opening), the internal canal of a hollow organ.

Lunule (Lat. *lunula*, a little moon), (1) a crescent-shaped mark, (2) the *frontal lunule*, a crescent-shaped opening above the antennae in the higher Diptera, marking the invagination of the ptilinum.

Malpighian tubules, the principal organs of excretion in insects (see p. 37)

Mandibles, the upper pair of jaws in insects (see p. 15).

Manubrium (Lat. = handle), (1) the basal segment of the spring in Collembola, (2) a chitinous structure attached to the ninth sternite in Dermaptera.

Maxillae (first maxillae), the second or lower pair of jaws in insects (see p. 15).

Maxillulae (Lat. = little jaws), see *Paragnaths*.

Melolonthoid, the term used to describe larvae of a curved, soft, grub-like form but with well-developed legs, like those of Scarabaeoid beetles (from *Melolontha*, one of the principal genera of Scarabaeidae).

Media (Lat. = middle), the fourth or middle vein of the insect wing, situated between radius and cubitus.

Membrane (1), of the wing, the more delicate chitinous portion between the veins, (2) in Hemiptera, the unhardened, membranous distal portion of the hemielytron.

Mentum (Lat. = chin), the second segment or fused basipodites of the labium or fused second maxillae.

Meso- (Gr. *mesos*, middle), the prefix used to denote the parts of the second thoracic segment or *mesothorax*, e.g. *mesonotum*, *mesopleuron*, *mesosternum*, etc. (see p. 18).

Mesoderm, see *Germinal Layers*.

Meta- (Gr. *meta*, after), the prefix used to denote the parts of the third thoracic segment or *metathorax*, e.g. *metanotum*, *metapleuron*, *metasternum*, etc. (see p. 18).

Metamorphosis (Gr. = change of form), see *Larva*.

Metapneustic (Gr. *meta*, after; *pneusis*, breathing), with spiracles at the posterior end of the body only.

Metapygidium, the second segment of the supra-anal plate in Dermaptera.

Micron (Gr. *mikros*, small), one-thousandth part of a millimetre; denoted by μ

Molar, a broad, more or less flattened tooth, used for grinding.

Moniliform (Lat. *monile*, necklace), like a string of beads.

Morphology (Gr. *morphe*, form; *logos*, discourse), that part of the science of biology which deals with the *form* of living things.

Naiad (Gr. *naiades*, water-nymphs), a term applied to the aquatic larvae of Dragonflies, Mayflies and Stoneflies.

Nasute (Lat. *nasutus*, having a large nose), the term applied to a certain caste of termites having the head produced forwards into a snout-like process (see p. 103).

Neoteinic (Gr. *neos*, new; *teino*, to distend), the term applied to royalties newly developed in a termite society on the occasion of the loss or death of the original royalties (see p. 103).

Nodus (Lat. = knot), a hinge on the costal margin of the wings of Dragonflies, formed at the distal end of the subcosta.

Nymph (Gr. *numphe*, nymph, maiden, chrysalis), the term applied, very unsuitably, to larvae of Ectopterygote insects in their later stages, when the wing-sheaths are developed.

Oblongum (Lat.), a special closed cell in the hindwing of certain Coleoptera (see p. 180).

Obsolescent (Lat. *obsolesco*, decay, go out of use), becoming worn out or obsolete.

Occiput (Lat.), the back of the head.
Ocellus (*Lat. = a little eye*), simple eyes, of which most insects have three, situated on the vertex of the head.
Oesophagus (Gr.), the gullet.
Ommata (Gr. *omma*, eye), the separate eye-elements of the degenerate compound eye in certain insect larvae.
Ommatidia (Gr. = little eyes), the separate eye-elements of the normal compound eye in insects.
Ootheca (Gr.), an egg-case, or capsule containing eggs.
Opisthomeres (Gr. *opisthe*, behind; *meros*, part), the collective term applied to the three segments of the supra-anal plate in Dermaptera.
Osmeterium (Gr. *osme*, a scent), a scent-organ; especially that situated on the prothorax of Papilionid caterpillars.
Ovary, the female gonad, in which the *ova* are produced.
Oviparous, laying eggs.
Ovipositor (Lat.), the egg-laying apparatus (see p. 26).
Ovum (Lat.=egg), the mature female germ-cell. Not to be confounded with the *egg*, which consists of the ovum hidden in a mass of yolk and protected by vitilline membrane and chlorion (see p. 39).

Palaeontology (Gr. *palaios*, ancient; *on*, stem *ont-*, existing thing; *logos*, discourse), that branch of biology which deals with extinct or fossil animals.
Palp or **palpus** (*Lat.=soft palm of hand*), *the segmented endopodites of the* first and second maxillae, used as feelers during the operation of feeding.
Palpifer (Lat. = palp-bearer), the small sclerite which is separated from the rest of the mentum in the labium (second maxillae) of some insects and bears the labial palp.
Palpiger (Lat. = palp-carrier), the small sclerite which is separated from the rest of the stipes in the maxillae of some insects and carries the maxillary palp.
Panoistic (Gr. *pas*, all; *oon*, egg), a type of ovarian tube (see p. 38)
Paraglossae (*Gr. para, alongside of; glossa, tongue*), *the outer pair of gnatho*-bases in the labium (fused second maxillae) of insects.
Paragnaths (Gr. *para*, and *gnathos*, jaw), two small processes developed at the sides of the hypopharynx (see p. 17); also sometimes called *maxillulae* in insects.
Parameres (Gr. *para*, and *meros*, part), a pair of processes of the ninth sternite, arising close to the base of the penis, in the males of insects other than Endopterygota.
Parapleura, the undivided pleura of the thorax in some Coleoptera, situated *ventrally on either side of the sterna.*
Paraproct (Gr. *para*, and *proktos*, anus), a pair of lobes bordering the anus latero-ventrally (see p. 27).
Parapsides (Gr. *para*, and *apsis*, an arch). In Hymenoptera, when the mesonotum is divided into a convex middle portion and two side-pieces, these latter are called *parapsides*, and the furrows which mark them off are known as the *parapsidal furrows*.
Pecten (Lat. = a comb), a comb of stiff hairs developed on the cubitus of the hindwing in some Lepidoptera.
Pectinate, comb-like; used of antennae with processes like the teeth of a comb.
Pedicel (*Fr. pédicelle, a foot-stalk*), *(1) the second segment of the antenna*, (2) the constricted part of the abdomen in Ants.
Penis (Lat.), the intromittent organ of the male; *penisfilum*, a thread-like extension of same.
Penunci (Lat. = penis-hooks), a pair of lateral processes arising from the penis in some Endopterygota.
Peripneustic (Gr. *peri*, around; *pneusis*, breathing), with spiracles on most of the segments.
Pharynx (Gr. = the throat), the part between mouth and gullet.
Phylogeny (*Gr. phulon, tribe, race*), *the study of the evolution of the various* tribes of animals, their descent and pedigree.
Phylum (Gr. *phulon*), one of the primary divisions of the Animal Kingdom.
Phytophagous (Gr. *phuton*, plant; *phagein*, to eat), feeding upon plants.
Pilifer (Lat. *pilus*, hair; *fero*, to bear), hairy processes developed from the sides of the labrum.

Planta (Lat. = sole of the foot), the flattened sole of the abdominal prolegs in Lepidopterous caterpillars.

Pleurites, the soft, membranous lateral portions of an abdominal segment.

Pleura (Gr. = sides), the lateral sclerites of a thoracic segment.

Podites (Gr. *pous*, foot), the separate pieces of a segmented appendage in the Arthropoda. Of these, the basal piece is called the *protopodite* (if divided into two, the distal one is called *basipodite*, the basal one *coxopodite*), the inner distal piece *endopodite*, the outer distal piece *exopodite*; an additional small piece sometimes present externally, attached to the coxopodite, is called the *epipodite*.

Polyphagous (Gr. *polus*, many; *phagein*, to eat), feeding on many things, omnivorous.

Polytrophic (Gr. *polus*, and *trophe*, nourishment), a type of ovarian tube, see p. 38.

Postnodal, a cross-vein situated between C and R, beyond the nodus, in Odonata (see p. 69).

Prepectus (Lat. *prae*, in front of, *pectus*, breast), a separate anterior piece of the mesepisternum, found in some Hymenoptera.

Pro- (Gr. and Lat. = before), the prefix used to denote the parts of the first thoracic segment or *prothorax*, e.g. *pronotum, propleuron, prosternum*.

Proboscis (Gr. = trunk), a somewhat elastic term used, in the Insecta, for any elongate type of mouth-parts.

Proctiger (Gr. *proktos*, anus; Lat. *gero*, to carry), a small papilla (reduced tenth abdominal segment) carrying the anus.

Prognathous (Gr. *pro*, before; *gnathos*, jaw), having the mouth-parts placed in front of the head.

Prolegs, paired appendages on the abdominal segments, used for walking.

Pronymph, the inactive, swathed larva which hatches from the egg in Dragonflies (see p. 72).

Propneustic (Gr. *pro*, before; *pneusis*, breathing), with spiracles only at the anterior end of the body.

Propodeum (Gr. *pro*, and *podeon*, the foot part, sheet of sail, etc.), the first segment of the abdomen in Hymenoptera, closely attached to the thorax and in front of the petiole.

Propygidium (Gr. *pro*, and *pygidium*); in Coleoptera, if the elytra are shortened so as to expose two hard tergites posteriorly, the more anterior of these is called the *propygidium*.

Protopodite, see *Podites*.

Pterostigma (Gr. *pteron*, wing; *stigma*, mark), a thickened area on the wing, situated more or less distally along the costal margin.

Pterothorax (Gr. *pteron*, and *thorax*), a term used to indicate the closely fused meso- and metathorax of certain winged insects.

Ptilinum (Gr.), the bladder-like vesicle in the head of the pupa of the higher Diptera, used for escaping from the puparium: in the imago, it is invaginated through the opening of the frontal lunule.

Pulvillus (Lat. = a little pillow); a small, usually pad-like process between the tarsal claws; when one only is present, it is usually termed *empodium*, when two are present, they are called *pulvilli*; in some Diptera, an empodium and two pulvilli are present together (see p. 336).

Punctum (Lat. = a point), a minute pit or point, as on the elytra of Coleoptera; *punctate*, covered with puncta.

Pupa (Lat. = a doll), the resting stage interposed between the active larval and imaginal stages in Holometabolous Insects. For definitions of *pupa libera, pupa incompleta, pupa obtecta* and *pupa coarctata*, see pp. 42, 43.

Puparium, the hardened, barrel-like skin of the larva in the higher Diptera, within which the pupa develops.

Pupiparous, bringing forth pupae, or larvae about to pupate.

Pygidium (Gr. *pugidion*, a little buttock), the single hard tergite exposed posteriorly in some Coleoptera with slightly shortened elytra.

Pygophor (Gr. *puge*, anus; *phero*, to bear), the specialized ninth abdominal segment in males of Hemiptera (see p. 141).

Quadrilateral, a special cell of quadrilateral form, situated between MA and Cu_1 in the region of the arculus in Zygopterous Dragonflies.

Radius (Lat. = a rod), the principal vein of the insect wing, situated below the subcosta and above the media. *Radial sector*, the posterior branch of the radius.

Raptorial (Lat. *raptor*, a robber), adapted for seizing prey.

Retinaculum (Lat.), a catch on the underside of the forewing in Lepidoptera, formed by stiff bristles, scales or projecting membrane, which engage the frenulum in flight.

Rostrum (Lat. = beak), the projecting anterior portion of the head in certain insects (e.g. Weevils), carrying the mouth-parts at its distal end.

Saccus (Lat. = a sack or bag), a bag-like organ.

Saltatorial (Lat. *saltator*, a jumper), adapted for jumping or springing.

Scape (Lat. *scapus*, a shaft or stem), the basal segment of the antenna.

Sclerite (Gr. *skleros*, hard), a separate hardened piece of the exoskeleton.

Scrobe (Lat. *scrobis*, a ditch), a groove situated on either side of the rostrum in Weevils, for reception of the scape of the antenna.

Scutellum (Lat.=a little shield), and **scutum** (Lat.=a shield), the two main divisions of the thoracic notum, the larger scutum being anterior to the smaller scutellum; in general, the term *scutellum* refers to that of the mesothorax.

Sensilla (Lat. dim of *sensus*, perception), a minute sense-organ.

Seta (Lat.), a bristle or stiff hair.

Sigmoid or **sigmoidal** (Gr. *sigma*, the letter S), curved like the letter S.

Specialized, see under *generalized*, of which it is the antithesis.

Sperm or **Spermatozoon** (Gr. *sperma*, seed), the mature male germ-cell.

Spermatheca (Gr. *sperma*, seed; *theke*, receptacle), the sperm-sac of the female insect, a special receptacle for storing the living spermatozoa received from the male.

Spiracle (Lat. *spiraculum*, air-hole), or *stigma* (Gr. = spot), a breathing-aperture, one of the openings of the tracheal system.

Squame (Lat. *squama*, a scale), a flat piece attached to an organ.

Sternum (Gr. = breast), the ventral part of a thoracic segment; *sternites*, ventral sclerites of any segment.

Stipes (Lat. = stalk), the second segment (basipodite) of the first maxilla.

Stria (Lat.=a groove), a longitudinal ridge or furrow; *striate*, longitudinally ridged or furrowed; *striole*, a short stria.

Stridulate (Lat. *stridulus*, a creaking or grating noise), to make a creaking, grating or hissing noise.

Strigil (Lat. *strigilis*, a scraper), a projecting organ on the fore tibia, used for cleaning the antenna.

Sub-, when used as a prefix, diminishes the intensity of a word, e.g. *subclavate*, more or less clubbed, *subfuscous*, somewhat smoky, *subfossil*, partially fossilized.

Subcosta, the second vein of the insect wing, situated next to the costa and just anterior to the radius.

Subgenital plate, a plate or process serving to cover the gonopore from below.

Subimago, in Mayflies, the first of the two winged instars, having opaque wings, and, usually, sexually immature.

Submentum, the basal segment or fused coxopodites of the labium or fused second maxillae.

Subulate (Lat. *subula*, an awl), awl-like.

Sulcus (Lat.), a groove.

Supra-anal plate or **telson**, a median appendage attached to the tenth abdominal tergite and covering the anus from above.

Supratriangle, see *triangle*.

Suranal plate, a strongly chitinized plate present on the dorsum of the last abdominal segment in certain larvae.

Suture (Lat. *sutura*, a seam), (1) the soft membranous portion between two sclerites or segments, (2) the line of junction of the two elytra in Coleoptera; *sutural margin*, the inner longitudinal border of the elytron which lies along the suture in the position of rest.

Tegmen (Lat. = a cover), (1) the hardened, leathery forewing in Orthoptera and Homoptera, (2) the ring- or tube-like male genitalia in Coleoptera.

Tarsus (Gr. = sole of foot), the distal portion of the insect leg, consisting of from one to five segments.

Tegula (Lat. = a tile), a small lateral sclerite of the mesonotum, situated just in front of the base of the forewing.

Telotrophic (Gr. *tele*, far; *trophe*, nourishment), a type of ovarian tube, see p. 38.

Telson, see *supra-anal plate*.

Tenent (Lat. *tenens*, holding), adapted for holding on, e.g. *tenent-hair*, a hair enlarged into a disc for holding at its apex.

Teneral (Lat. *tener*, tender), the term applied to the condition of the freshly emerged or immature imago.

Terebra (Lat.=boring-tool), the part of the ovipositor used for boring.

Terga or **tergites** (Lat. *tergum*, the back), upper or dorsal sclerites or parts of segments.

Termen (Lat. = margin), the distal margin in a triangularly shaped wing.

Termitarium, the nest of a colony of white-ants.

Theca (Gr. = receptacle), a chitinous piece of the Dipterous proboscis, situated basally from the labella.

Thorax (Gr. = the breast), the middle division of the insect body, between head and abdomen; it bears the legs and wings.

Tibia (Lat.=shin-bone), the fourth segment of the insect leg, situated between *femur* and *tarsus*.

Tormae, the side-pieces of the epipharynx in Diptera.

Tornus (Lat.), the angle between posterior and distal margins in a triangularly shaped wing.

Torulus (Lat.=a little couch or bed), the socket of the antenna.

Trachea (Gr. *tracheia*, windpipe), an air-tube.

Triad (Gr. *trias*, the number three), a special form of branching of the main veins in the wings of insects, see p. 23.

Triangle and **supra-triangle,** the lower and upper portions respectively into which the quadrilateral or discoidal cell of Anisopterous Dragonflies is divided (see pp. 74, 80).

Trilobe, having three lobes.

Triungulin (Lat. *tres*, three, and *ungula*, a claw), the term applied to the first instar larva of certain insects, characterized by its campodeiform shape and its legs ending apparently in three claws (actually two claws and an elongate empodium).

Trochanter (Gr.), the small second segment of an insect's leg, situated between coxa and femur.

Tubercle (Lat. *tuberculum*, a little swelling), a small raised area on a surface; *tuberculate*, covered with tubercles.

Types, the actual specimens from which the description of a new species is made. If the description is made from a single specimen, this specimen is called the *holotype*; the first specimen of the opposite sex described is termed the *allotype*; any remaining specimens of the same series, studied along with these and taken from the same locality, are called *paratypes*. If the description is made from the whole series, without designating any particular specimen, then each specimen of the series is correctly termed a *co-type*.

Vena dividens, the concave vein Cu_2 when it lies in the furrow dividing a definite *clavus* (q.v.) from the rest of the wing, as in Cockroaches.

Vertex (Lat. = crown of the head), the uppermost portion of the epicranium, usually carrying the ocelli.

Vesicle (Lat. *vesicula*), a little bladder.

Vibrissa (Lat.=hair in the nose), a strong bristle situated near the mouth in some Diptera.

Viviparous (Lat.), bringing forth living young.

Xerophytic (Gr. *xeros*, dry; *phuo*, to grow), adapted for living in a dry climate.

APPENDIX II

ABBREVIATIONS OF AUTHORS' NAMES USED IN THIS BOOK

(N.B. A number of authors' names are also given in full, either because they are short, e.g. Lea, Leach, or because they occur only once or twice, e.g., Brullé, Bouché.)

A. & S.	Amyot & Serville
Alex.	Alexander, C. P.
Ashm.	Ashmead
B-B.	Bethune-Baker
Bd.	Boisduval
Berg.	Bergroth
Bern.	Bernard
Bez.	Bezzi
Big.	Bigot
Bks.	Banks, Nathan
Blanch.	Blanchard
Blkb.	Blackburn
Boh.	Bohemann
Bol.	Bolivar
Bon.	Bonelli
Bouv.	Bouvier
Br.	Brauer
Bred.	Breddin
Brn.	Broun
Brunr.	Brunner von Wattenwyl
Burm.	Burmeister
Butl.	Butler
Cam.	Cameron, T.
Cand.	Candèze
Carp.	Carpenter, G. H.
Cart.	Carter, H. J.
Cast.	Castelnaud
Caud.	Caudell
Champ.	Champion
Chaud.	Chaudoir
Chev.	Chevrolat
Coq.	Coquillet
Cram.	Cramer
Curt.	Curtis
D. T.	Dalla Torre
Dall.	Dallas
Dbd.	Doubleday
Dist.	Distant
Dodd.	Dodd, A. P.
Don.	Donovan
Dr.	Drury
Dup.	Duponchel
E. P.	Esben Petersen
Eat.	Eaton
Edw.	Edwards, F. W.
Ehr.	Ehrhorn
Em.	Emery
Er.	Erichson
Er. Sm.	Smith, Erwin F.
Esch.	Escherich
F. B. W.	Buchanan White, F.
F. & H.	Ferguson & Hill
Fabr.	Fabricius
Fairm.	Fairmaire
Fall.	Fallen
Feld.	Felder
Fered.	Fereday
Ferg.	Ferguson, E. W.
Fhs.	Fahraeus
Fleut.	Fleutiaux
Fons.	Fonscolomb
Forst.	Foerster
Fried	Friedrichs
Frogg.	Froggatt, W. W.
Gdg.	Goding
Germ.	Germar
Gerst.	Gerstaecker
Gieb.	Giebel
Gir.	Girault
Glov.	Glover
Gn.	Guenée
Grav.	Gravenhorst
Guér.	Guérin-Méneville
Gyll.	Gyllenhal
H. Sch.	Herrich-Schaeffer
Hal.	Haliday
Hald.	Haldeman
Hamps.	Hampson
Hans.	Hansemann
Hardy.	Hardy, G. H
Harr.	Harrison, L.
Hausm.	Hausmann
Haw.	Haworth
Hew.	Hewitson
Heyd.	Heyden
Hill.	Hill, G. F.
Horv.	Horvath
How.	Howard
Hub.	Hubner
Huds.	Hudson, G. V.
Hutt.	Hutton
J. & T.	Johnstone & Tiegs

Jord.	Jordan
Kby.	Kirby, W. F.
Kieff.	Kieffer
Kirk.	Kirkaldy
Kuw.	Kuwano
L.	Linnaeus
L. & G.	Laporte & Gory
Lam.	Lamarck
Latr.	Latreille
Le Guil.	Le Guillou
Lew.	Lewin
Lind.	Lindemann
Low.	Lower, O.
Lubb.	Lubbock
Luc.	Lucas, T. P.
M. W.	Meade-Waldo
Macl.	Macleay, Sir W.
Macq.	Macquart
Marsh.	Marshall, P.
Mart.	Martin, René
Mask.	Maskell
McL.	McLachlan
Meig.	Meigen
Meij.	de Meijere
Meyr.	Meyrick
Mill.	Miller, D.
Mocs.	Mocsary
Mont.	Montandon
Morl.	Morley, C.
Mot.	Motschulsky
Mull.	Mueller
Muls.	Mulsant
Nav.	Navas
Newm.	Newman
O. S	Osten-Sacken
Ol.	Olivier
Oll.	Olliff
Osb.	Osborne
P. & S.	Le Pelletier & Serville
Pasc.	Pascoe
Perk.	Perkins
Philp.	Philpott
Pict	Pictet
Planch.	Planchon
Poll.	van der Poll
R. D.	Robineau-Desvoidy
R. & J.	N. Rothschild & K. Jordan
R. Turn.	Turner, R. E.
Rag.	Ragonot
Ramb.	Rambur
Ratz.	Ratzeburg
Reaum.	Réaumur
Redt.	Redtenbacher
Reut.	Reuter
Ric.	Ricardo
Rogen.	Rogenhof
Rohw.	Rohwer
Rosen.	Rosenstock
Roth.	Rothschild, W.
Roths.	Rothschild, N.
Rott.	Rottemburg
S. & J.	Saunders & Jekel
Saund.	Saunders
Sauss.	de Saussure
Sc.	Scott, A. E.
Sch.	Schiner
Schh.	Schoenherr
Schiff.	Schiffermuller
Schl.	Schultzer
Schlett.	Schletterer
Schr.	Schrader
Schreib.	Schreibers
Schrk.	Schrank
Sel.	de Selys-Longchamps
Serv.	Serville
Shuck.	Shuckard
Sign.	Signoret
Silv.	Silvestri
Sjost.	Sjoestedt
Sk.	Skuse
Sm.	Smith, F
Spin.	Spinola
Steph.	Stephens
Stn.	Stainton
Sulz.	Sulzer
Swed.	Swederus
Swin.	Swinhoe
Szepl.	Szépligeti
Tayl.	Taylor, F. H.
Targ.	Targioni-Tozzetti
Thoms.	Thomson
Thunb.	Thunberg
Till.	Tillyard
Tonn.	Tonnoir
Tr. & Neum.	Trouessart & Neumann
Turn	Turner, A. J.
Tull.	Tullberg
Ulm.	Ulmer
Vall.	Vallot
Voll.	Vollenhoven
W. S. M.	Macleay W. S.
Walk.	Walker, F.
Wall.	Wallengren
Warr.	Warren
Wat.	Waterhouse, G. A.
Waterh.	Waterhouse, C. O.
Weele.	van der Weele
Wh.	White, Adam
White.	White, Arthur
Wied.	Wiedemann
Wwd.	Westwood
Zell.	Zeller

INDEX

In this Index, all Orders, Suborders, Families, Subfamilies and Genera are usually only indexed once, the reference being to the page on which each is dealt with in detail; where more than one reference is given, it is to be understood that the reference first quoted is the principal one. References preceded by capital letters refer to text-figures, e.g. R63, Z17; references to figures in the plates are given as follow:—pl.12,f.3, etc.; references followed by the letter n refer to footnotes on the pages mentioned.

Abdomen, 25, 9; end-segments of, A10, A11
Abies, insects on, 172
Abispa, 295; *ephippium*, 295
Ablerus, 278
Abraxas, 451
Abricta, 161; *aurata*, 161; *curvicosta*, 161
Acacia (Wattle), insects associated with, 173, 202, 216, 218, 229, 233, 236, 240, 274, 413, 423, 425, 426, 427, 443, 463, 465, 466, 488; *aneura*, 139; *baileyana*, 171; *decurrens*, 165, 276, 318
Acalles, 245
Acallopais rudis, 245
Acalyptrata, 369
Acanaloniidae, 165
Acanthaclisis, 324; *fulva*, 324; *fundata*, 324; pl.24,f.8; larva, U5; *peterseni*, 324
Acanthanura, 56
Acanthaspinae, 151
Acanthiidae, 154
Acanthoconops, 352; *myersi*, 352
Acanthoderus, 94; *prasinus*, 94
Acanthodoryctes morleyi, 269
Acantholepsis, 290
Acantholophus, 242
Acanthoponera, 288; *brauni*, 288
Acanthopsylla, 384
Acanthoserphus, 282; *albicoxa*, 282
Acanthosomatinae, 148
Acanthucus, 165; *trispinifer*, 165
Accessory glands, 38
Acerentulus, 52
Acerentomidae, 52
Acerentomum, 52; *doderoi*, 52, C1
Acetabulum, 19, 178, 189
Acetic ether, 488
Achaea janata, 443; pl.35,f.6; *melicerta*, 443
Achias, 371; *amplividens*, 371, W67
Achilidae, 169
Achilioxiidae, 165
Achilus flammeus, 169; pl.11,f.17
Achorutes viaticus, 55
Achorutinae, 55
Achthosus westwoodi, 222
Aciagrion, 77
Aclistoides, 281
Acmonotus, 324; *incusifer*, 324; *magnus*, 324
Acolomorpha, 283
Acolus, 283
Acontiinae, 442
Acosmeryx anceus, 448
Acraea andromacha, 462; pl.43,f.14
Acraeinae, 462
Acrantus, 239
Acrida turrita, 98, G10
Acridiidae, 97
Acridiinae, 98
Acridioidea, 94
Acridopeza reticulata, 95; female, pl. 7,f.9
Acrocercops, 422; *cuneatella*, 422; *macaria*, 422
Acroceridae, 360
Acroclita, 427; *trimerodana*, 427; pl. 28,f.43
Acronyctinae 441
Acrophylla, 94; *tesselata*, 94; pl.7,f.7
Acropteris, 445
Acrotelsa, 49
Actina, 359
Actinus, 209; *imperialis*, 209; *macleayi*, 209; pl.17,f.25
Actora bipunctata, 371
Aculeae, 21, 399
Acyphas, 440; *chionitis*, 440; pl.33,f.15
Addaea, 431; *pusilla*, 431; pl.28,f.55
Adeliinae, 222
Adelinae, 420
Adelium, 222; *striatum*, 222; pl.18,f.9
Adelotopus, 192; *castaneus*, 192; pl. 16,f.2
Ademosyne, 475, 186, 472, 477
Adephaga, 190
Admiral Butterflies, 463
Adolph, G. E., 22
Adrisa, 148
Aedeagus, 27
Aedes, 351; *albo-annulata*, 351; *argentea*, 351; *notoscripta*, 351; *vigilax*, 351
Aegeriidae, 424
Aemona, 233; *villosa*, 233

Aenictus, 288
Aeolocosma, 419n
Aeolothripidae, 138
Aeolothynnus, 294
Aequipalpia, 390
Aëroplana mirabilis, 476
Aëroplanoptera, 477
Aeschna brevistyla, 84; pl.4,f.4; morphology, F1; mouth-parts, F2; larva, F5
Aeschnidae, 83
Aeschninae, 83
Aeschnoidea, 82
Aeschnidiidae, 477
Aeschnidiopsis flindersiensis, 477
Aesernia australasiae, 236; pl.15,f.28
Aesiotes, 242; *leucurus*, 242
Aethyssius, 223; *viridis*, 223; pl.15,f.8
After-body, 178
Agallia, 163; parasites of, 251
Agamerion, 274
Agamerionella, 274
Agandecca annectens, 169
Agaontidae, 275
Agapophytus albopunctatus, 362; pl. 25,f.15
Agarista agricola, 441
Agaristinae, 441
Agasma semicrudum, 225; pl.15,f.9
Agastegnus, 246
Agathia lactata, 451; pl.27,f.37
Agathinus, 243
Agathodes, 432
Aglossa, 429n; *cuprealis*, 433; *pinguinalis*, 433
Aglycyderidae, 247
Aglycyderoidea, 246
Aglycyderes, 247, 246; *badius*, 247, *setifer*, 247; *wollastoni*, 247, R85
Agonischius, 220
Agonoscelis rutila, 149; pl.11,f.8
Agriidae, 80
Agrilinae, 216
Agriocnemis, 77
Agrioidea, 78
Agriomyia, 294
Agrion, 80n; *puella*, 80n
Agrionoptera, 86
Agriophara confertella 426; pl.30,f.3
Agroeciinae, 95
Agromyza, 372; *phaseoli*, 372
Agromyzidae, 372
Agrotera, 432; *pictalis*, 432; pl.27,f.18
Agrotinae, 442
Agrotis infusa, 442; pl.32,f.15; *spina*, 442; *ypsilon*, 442
Agrypninae, 220
Agrypnus, 220
Alaptus, 280; *newtoni*, 280
Alary muscles, 33
Alastorinae, 305
Alaus, 220; *gibboni*, 220
Alcides, 245
Alcidinae, 245
Alcidis zodiaca, 445; pl.36,f.3; wings, Z44
Alcis, 450n
Alcohol, 498; absolute, preparation of, 497
Alder-flies, 313, 308
Alectoria superba, 95; pl.6,f.6
Aleocharinae, 209
Aleurocanthus banksiae, 172
Aleurodidae, 172
Alexander, C. P., 343n
Alimentary System, 30
Alitrunk, 253, T4-T6
Allaorus, 246
Allelidea, 213
Allocharis, 236
Allodape, 305; *diminuta*, T52
Allomachilis froggatti, 49
Alloparnus, 216
Allophytopsis, 371
Allotria, 271
Aloe pith, use of, 492
Alphitobius diaperinus, 223; *laevigatus*, 223
Alucita, 429; *aptalis*, 429; *furcatalis*, 429; *lacteipennis*, 429; pl.33,f.8; *lycosema*, 429; pl.33,f.9
Alula (Coleoptera), 186, 197; (Diptera), 338
Alydinae, 148
Alysia, 270
Alysiid, head and jaws, T20
Alysiidae, 270
Amalactinae, 243
Amarosoma, 223
Amarygminae, 223
Amarygmus, 223; *zelandicus*, 223
Amata, see *Syntomis*, 444
Amatidae, 444
Ambeodonta tristis, 233
Amblycera, 133
Amblyopone, 288
Amblytetes, 269
Ambrosia Beetles, 238
Ameletus, 62; *ornatus*, 62; pl.10,f.1; venation, E1; *perscitus*, pl.2,f.1
Ametrocephala, 234
Amiota, 373
Ammophila, see *Sphex*, 300
Amoenia leonina, 376; pl.25,f.29
Amorbinae, 147
Amorbus, 147; *robustus*, 147; pl.12, f.4
Amorphocephalus, 241
Amphaces, 148
Amphibolia, 376; *valentina*, 376
Amphidorinae, 222
Amphigerontia, 130; *formosa*, 130; pl. 11,f.6
Amphineurus, 348; *insularis*, wing, W23
Amphipterygidae, 79
Amphithera heteroleuca, 422; pl.28,f. 15, 16
Amphitheridae, 422
Amplexiform coupling, 402
Ampulicidae, 298
Amycterinae, see Phalidurinae, 242

Amydala, 245
Anabarrhynchus, 362; *bilineatus*, 362; *montanus*, 362, W44
Anacharis, 271; *australiensis*, 271; *zelandica*, 271
Anagrus, 280
Anagyris, 277
Anal cell, 338n; fan, 88; forceps, 181; furrow, 25; loop, 80; style, 141; supplement, 80; veins, 22; secondary anal vein, 70, 80
Anamesia, 91
Anaphacis java teutonia, 464
Anaphes, 280
Anaphothrips striatus, 139
Anarciarthrum, 243
Anarsia, 419n
Anastellorhina stygia, 375, pl.25,f.26; antenna, W1,F; larva, W17; mouth-parts, W4; wing, W66
Anax, 83; *papuensis*, 84; pl.4,f.5
Andrenidae, 303
Andrenopsis, 303
Andriscus, 148
Androconia, 399
Androgynella, 304
Anemosa, 433
Anemosetidae, 414
Anerastia, 434; *virginella*, 434
Aneurystypus, 231
Angophora, insects associated with, 217, 218, 231, 425, 488
Angoumois Grain Moth, 426
Anilara, 218
Anilicus, 220
Anisocentropus, 392; *latifascia*, 392; pl.26,f.9
Anisodes, 452
Anisolabis, 111; *littorea*, 111; pl.7,f. 16; parts, J4
Anisopodidae, 349
Anisops, 157; *assimilis*, 157, Q17; *doris*, 157; *hyperion*, 157; *stali*, 157
Anisoptera, 80
Anisoscelinae, 147
Anisotoma, 208
Anisozygoptera, 73, 74
Anisynta, 457
Ankylopteryx, 318
Anobiinae, 215
Anobium, 215; *domesticum*, 215; *punctatum*, 215; *striatum*, 215
Anochetus, 288
Anomoses hylecoetes, 414
Anomosetidae, 414
Anopheles, 351
Anophelinae, 351
Anoplius, 293
Anoplognathus, 230; *olivieri*, 230; *porosus*, 230; *viridi-aeneus*, 230, R61
Anoplostethus opalinus, 230
Anoplura, 131, 5
Anostostoma, 97; *australasiae*, 97, G9
Ant-lion lacewings, 323
Ant-lions, 323
Antarctic connection, 478, 479
Antarctophthirinae, 135
Antarctophthirus microchir, 135; *ogmorhini*, 135
Antarctopria latigaste, 282
Antargidium, 265
Anteclypeus, 12
Antennae, 14, 37, A4; (Diptera), W1
Antenodals, 69
Anteon, 285
Anterior Median, 58, 67, 89
Anthela, 439; *acuta*, 439; pl.32,f.7; wings, Z39; *gueneei*, 439; *oressarcha*, 439; pl.35,f.2
Anthelidae, 438
Antheraea, 454; *astrophela*, 454; *eucalypti*, 454; pl.35,f.9; larva, Z53; wings, Z52; *helena*, 454; *janetta*, 454; *loranthi*, 454; *saccopaca*, 454
Anthicidae, 223
Anthicus, 223
Anthobosca, 295; *flavicornis*, 295; *lagardei*, 295, T45
Anthoboscinae, 295
Anthocoridae, 153
Anthoglossa, 302
Anthomyia, 374
Anthomyiidae, 374
Anthomyza, 372
Anthonominae, 245
Anthonomus, 245
Anthophila, 301
Anthophora, 304; *bombiformis*, 304; *cingulata*, 304; mouth parts, T3,F; *pulchra*, 304; pl.20,f.15; pl.21,f.31
Anthophoridae, 304
Anthracinae, 364
Anthrax, 364
Anthrenus, 206, 496; *varius*, 206
Anthribidae, 239
Anthribus, 240; *vates*, 240, R72
Antimimistis, 452, 415n, 445
Antipodes Island Parakeet, parasite of, 384
Antisquame, 336
Antochinae, 348
Antonina australis, 174
Ants, 286, 287; attending larvae, 464, 465, 466; mimics of, 147, 234
Ants' nests, 489; insects in, see Inquilines, also 422, 464
Anus, 27, 32
Aochleta, 425
Aolles, 245
Aonychus, 245
Aorta, dorsal, 33
Apachyidae, 111
Apachyoidea, 111
Apachyus australiae n.sp., 112; description, 112, appendix, J3; pl.7,f. 17; parts, J5
Apanesia, 285
Apanteles, 269
Apate, 204
Apatolestes, 359

Apaturinae, 463
Apellatus, 223
Apertum, 180
Apex, of wing, 25
Aphaenogaster, 289
Aphaninae, 147
Aphaniptera, see Siphonaptera, 380
Aphanisticus, 217
Aphonogmus, 283
Aphanomerus, 283; *bicolor*, 283, T35
Aphelininae, 278
Aphelinoidea, 279
Aphelinus, 278; *mali*, 278, 172
Aphelomera, 354
Aphelopus, 285
Aphelotoma, 298; *rufiventris*, 298; *tasmanica*, 298
Aphididae, 171
Aphilon, 236
Aphiochaeta, 366; *nebulosa*, 366; *omnivora*, 366; wing, W59
Aphis abietina, 172; *bakeri*, 172; *brassicae*, 172; parasite of, 283; *coprosmae*, 172, Q37; *gossypii*, 172; *nerii*, 172; *persicae-niger*, 172
Aphodiinae, 228
Aphodius, 229
Aphrophila, 348
Aphycus, 277; *lounsburyi*, 277, T27
Aphylinae, 148
Aphylum, 148
Apical forks, 388
Apidae, 305
Apiinae, 243
Apiocera, 363; *asilica*, 363; pl.25,f.19; wing, W54; *bigoti*, 363
Apioceridae, 363
Apiomorpha, 173; *duplex*, 173, Q38; gall, pl.14,f.1; *munita*, 173; gall, pl.14,f.5; *pileata*, 173; galls, pl.14, f.2, 3; *pomiformis*, 173; *strombylosa*, 173; galls, pl.14 f.4
Apiomorphinae, 173
Apion, 244; *metrosideros*, R76
Apirocalus cornutus, 242
Apis mellifera, 305; race *ligustica*, 305
Apistomyia, 355
Aplochlora, 451; *vivilaca*, 451; pl.27, f.34
Aploschema, 445; *discata*, 445; pl.33, f.10
Apocampta, 359
Apochrysa, 318
Apochrysinae, 318
Apocrita, 265
Apodemes, 11, 30
Apoidea, 301
Aporus, 293
Appendages, 11, 28
Appendix dorsalis, 27
Appias, 464
Apple Leaf-hopper, 163, Q26
Apples, pests of, 163, 172, 174, 427, 428
Aproïda balyi, 237
Aprosita obscura, 439; pl.30,f.19
Aprostocetus, 278
Apsona muscaria, 360; pl.2,f.26
Ptericola, 134; *gadowi*, 134, O2
Apterina, 373
Apterobittacus, 332n
Apterygota, 3
Apteryx, parasites of, 134; *australis*, 134
Arachnocampa luminosa, 352
Arachnomyia, 365
Aradellus, 151
Aradidae, 149
Aradinae, 150
Aradoidea, 149
Aradus australis, 150
Araucaria Cunninghami, insects on, 243
Archibasis, 77
Archichauliodes, 313; *dubitatus*, 313; pl.22,f.1; larva, U2; pupa, U3; wings, U1; *guttiferus*, 313
Archimantis latistylus, 93; *monstrosa*, 93
Archipanorpa magnifica, 475
Archipanorpidae, 330
Archizygoptera, 73
Arctiidae, 444
Arctiinae, 444
Arctocephalus hookeri, parasite of, 135
Arctocorisa, 158; *arguta*, 158, Q18; *australis*, 158
Arculus (Odonata), 69; (Diptera), 338
Ardices glatignyi, 444; pl.33,f.17
Ardiosteres, 421
Areocel, 401
Areocryptus bellus, 246, R83
Areola postica, 127
Areole, 400
Areolet, 271
Argina cribraria, 440; pl.30,f.21
Arginae, 265
Argiolestes, 78, 70; *amabilis*, 78; *chrysoïdes*, 78; *griseus*, 78; *icteromelas*, 78; pl.3,f.3; larva, F11.D; venation, F9
Argosarchus, 94; *horridus*, 94; pl.7, f.8
Argynnina tasmanica, 462; pl.43,f.9
Argynnis hyperbius inconstans, 463
Argyramoeba, 364
Argyria, 433; *pentadactyla*, 433
Argyrophenga antipodum, 463; pl.38, f.29
Argyroploce, 427; *illepida*, 427; *miltographa*, 427; pl.28,f.44
Arhopala, 465
Arhopalinae, 465
Ariathisa hydraecioides, 411; pl.32, f.10
Aridaeus thoracicus, 234; pl.15,f.24
Ariphron, 294; *petiolatus*, 294
Arista, 334
Aristeis hepialella, 425; pl.28,f.28

Aristolochia, insects on, 458, 460
Aristopsyche, 476; *superba*, ZA9
Aristotelia (Lepidoptera), 426
Aristotelia, insects on, 413
Arixenia, 108, 110
Arixenina, 110
Army Worm, 442
Arnomus, 235
Arocatus, 146; *ruficollis*, 146; pl.2,f.8
Arolium, 19
Arotrophora, 428; *arcuatalis*, 428; *atimana*, 428
Arpactidae, 299
Arpactus, 299; *carbonarius*, 299; *chrysozonus*, 299, T48
Arrhopalites davidi, 56
Arsipoda, 236
Arthrolysis, 277
Arthropleona, 55
Arthropoda, 1
Arthropterus, 194; *brevis*, 194; *westwoodi* parts, R21; *wilsoni*, 194; pl.17, f.17
Articerus, 210; *foveicollis*, 210; pl.16, f.6
Asaphodes, 452
Ascalaphidae, 324
Ascalaphus, 324n
Ascelis, 173
Aschiza, 365
Asciura, 372
Asclepias, insects on, 462
Asilidae, 362
Asilinae, 362
Asilis, 212
Asiloidea, 361
Asilus, 363; *rufiventris*, 363
Asobara, 270
Asopinae, 148
Aspidiotus, 174; *hederae*, 174; *perniciosus*, 174
Aspidomorpha, 237
Assassin-bugs, 150
Astacops, 146
Asteia, 373, 370n
Asterochiton vaporarium, 172
Asterolecanium, 174; *variolosum*, 174; parasite of, 278
Asthena, 452
Asthenothynnus, 294
Astracus, 218
Asura, 444; *lydia*, 444; pl.32,f.21
Atalophlebia, 63; *costalis*, 63, A11; pl.10,f.5; larva, E3; venation, E6; *cruentata*, 63; *dentata*, 63; pl.2,f.2; *versicolor*, 63; pl.10,f.4
Atelcopterus longiceps, 285
Atelicus, 242
Atelura, 184; *cursitans*, 49
Aterpinae, 242
Aterpus, 242
Athemistus, 234
Atherimorpha, 358
Atlas Moths, 454
Atomaria lindensis, 202
Atomotricha, 424
Atractocera, 213
Atrium, 33
Atropidae, 129
Atropos pulsatoria, 129, 496
Attacus edwardsi, 454
Attelabinae, 243
Atteva niphocosma, 422; pl.27,f.9
Atyphella, 213; *brevis*, 213, R43; *lychnus*, 213
Auchenorrhyncha, 159
Aucklandobius, 119
Auger Beetles, 203
Augomela hypochalcea, 236
Aulacaspis rosae, 174
Aulacinae, 268
Aulacocyclus 226; *edentulus* 226; *teres*, 227; pl.18,f.27
Aulacophora hilaris, 236, R66
Aulacopris reichei, 228; pl.18,f 30
Aulacothroscus elongatus, 219
Aulax hypochaeridis, 271
Auletes, 244
Auricles, 71
Australian Admiral, 463; Copper, 466; Painted Lady, 463; Tortoiseshell, 463
Australophyra analis, 374
Austroaeschna, 84; *parvistigma*, 84; pl.4,f.2; venation, F18
Austroagrion, 77; *cyane*, 77
Austrocnemis, 77
Austrodictya corbouldi, 479
Austrogomphus, 83; *guérini*, 83; *ochraceus*, 83; larva, F20,B
Austro-Gondwanan Faunas, 473, 477; table of, 482
Austrogoniodes, 134
Austrogynacantha, 84
Austroleptis, 358
Austrolestes, 78, 70; *analis*, 78; *annulosus*, 78; *cingulatus*, 78; pl.3,f.5; larva, F11,E; venation, F10; *colensonis*, 78; *leda*, 78; head, F1,D
Austromantispa, 319
Austromicron, n.g., defined 279n; *zygopterorum*, n.sp., described 279n, T29
Austromiris, 153
Austronymphes, 322
Austroperla, 118; *cyrene*, 118; pl.10, f.10; wings, K4
Austroperlidae, 118
Austropetalia patricia, 84; pl.11 f.2; larva, F20,C
Austrophlebia costalis, 84
Austrosapromyza, 371
Austrosialis ignicollis, 313
Austrosimulium, 355; *australense*, 355
Austrosticta fieldi, 76
Austrostylops, 250; *gracilipes*, 251
Austrothemis nigrescens, 86; pl.4,f.7
Axelsonia, 56
Axillary, 21
Axionicus insignis, 245
Azelina, 451; *fortinata*, 451; pl.38,f.15; *gallaria*, 451

Bacillus pestis, carrier of, 382
Back-swimmers, 157
Bacon Beetle, 206
Badamia exclamationis, 456
Baeinae, 283
Baëtidae, 64
Baëtis soror, 64
Bag Moths, 435
Baits for insects, 489
Balaninae, 245
Balaninus, 245; *amoenus*, 245, R81
Balanophorus, 213
Balantiucha decorata, 445; pl.28,f.58, 59
Balcus niger, 213
Banana Aphis, 172
Banana Borer, 245
Bandicoot, parasites of, 384
Banksia, insects connected with, 219, 425, 446; *serrata*, 428
Banksia Beetles, 219
Barantola, 424
Bardee, 233
Bardistus cibarius, 233
Barca, 424
Bargylia, 151
Baridiinae, 245
Bark-collecting, 488
Baryconus, 283
Basal cell, 401
Basement membrane, 30
Bassus laetatorius, 269
Bat-fleas, 384
Bat-flies, 378
Bathypogon, 362
Bathymetis, 269
Batocera, 234, 489; *boisduvali*, 234; pl.19,f.12; *frenchi*, 234
Batozonus tricolor, 292; pl.20,f.10
Batrachedra, 426
Batrachomyia nigritarsis, 373
Bean Weevils, 237
Beckerina, 366
Bed Bug, 153
Bedellia somnulentella, 421
Bee-bread, 301
Bee-flies, 363, 364
Bee Hawk-moths, 448
Bee-killer, 150
Bee Moths, 434
Bee-parasite, 367
Bees, 301
Beetles, 176
Belinae, 243
Bell Moths, 427
Belmont fossil bed, 469, fauna, table of, 482
Belmontia mitchelli, 472, ZA4
Belostomatidae, 157
Belus suturalis, 243; pl.19,f.22
Belytidae, 281
Bembex, 299; *furcata*, 299; pl.21,f.26; *palmata*, 300; *raptor*, 300; *tridentifera*, 300; *variabilis*, 300; *vespiformis*, 300
Bembecidae, 299
Bembidiinae, 191, 192
Bent-wing Moth, 413, pl.29
Benzene, use of, 497
Bequaert, J., 295n
Bergroth, E., 151
Berinae, 359
Beris, 359
Berlèse, A., 52
Berosus, 197
Berotha, 316; *gracilipennis*, pl.22,f.6
Berothidae, 315
Berytidae, 148
Bethyloidea, 284
Bethylidae, 285
Bettongia, parasite of, 383
Betyla fulva, 282
Bibio, 356; *imitator*, 356
Bibionoidea, 354
Bibionidae, 356
Bignonia, insects on, 429
Bindahara, 465
Binomial System, 2
Biprorulus bibax, 149; pl.6,f.11
Biscuit Weevil, 215
Bittacidae, 331
Bittacus, 332
Blackberry, insects on, 428
Black-boys, 234
Black Cicada, 162
Black Peach Aphis, 172
Black Scale, 174
Bladder Cicadas, 161
Bladder-flies, 360
Blastobasinae, 425
Blastobasis, 425
Blastophaga psenes, 276
Blastophagidae, 275
Blattella, 91; *germanica*, 92
Blattidae, 91
Blattinae, 91
Blattoidea, 91, 481
Blenina, 442
Blepegenes, 222; *aruspex*, 222
Blepharoceridae, 355
Blepharoptera, 371
Blepharotes, 363; *coriarcus*, 363; pl. 20,f.24; *splendidissimus*, 363; pl.25, f.18
Blés Solution, 488, 497
Blister Beetles, 226
Blood, 33
Bloodwood, galls on, 278
Blow-fly, Blue-striped, 375; Golden-haired, 375
Blow-flies, 375, 343
Blue Ant, 294
Blue-bottles, 375
Blue Gum, see *Eucalyptus globulus*
Blues, 465, 464
Boarmia, 450; *canescaria*, wings, Z49; *dejectaria*, 450; pl.31,f.23; *luxaria*, 450; pl.39,f.8; *pelurgata*, 450; *productata*, 450; larva, Z12; *pungata*, 450; pl.31,f.22; *rudiata*, 450
Boarmiidae, 450
Body-wall, 30

Bogong Moth, 442
Bolboceras, 229; *capreolus*, 229; *rhinoceros*, 229
Bolitophaginae, 222
Bolitophila, 352
Bombadier Beetle, 192
Bombus hortorum, 305; *lucorum*, 305; *ruderatus*, 305; *terrestris*, 305
Bombycidae, 453
Bombycoidea, 453
Bombyliidae, 363
Bombyliinae, 364
Bombylius, 363, 364; *pictipennis*, 364
Bombyx mori, 453
Bondia, 428; *caseata*, 428; pl.28.f.51; *nigella*, 428
Book-lice, 126, 129
Boopia, 134; *notafusca*, 134, Q1
Boopiidae, 134
Borboridae, 373
Borborus, 373
Boreidae, 329, 330
Boreoides subulatus, 360; pl.25.f.10.11
Borer, furniture, 215
Boriomyia, 318
Borkhausenia, 425; *chrysogramma*, 425; pl.28.f.34; pl.38.f.2; *plagiatella*, 425; pl.28.f.33
Bostrychidae, 203
Bostrychopsis jesuita, 204, pl.18.f.4
Bot-flies, 376, 343
Bothrideres, 200
Bothriomyrmex, 290
Bothroponera, 288
Brachaspis, 98; *collinus*, 99
Brachopsis, 234
Brachycera, 357
Brachychiton (Kurrajong Tree), insects on, 171, 202, 432
Brachyderinae, 241
Brachydiplacinae, 86
Brachymera, 206
Brachymeria, 274; *aurea*, 274, T23; *hercules*, 274
Brachyninae, 192
Brachyolus, 242
Brachypeplus auritus, 202; pl.16.f 11
Brachyrhynchus, 150
Brachyscelinae, 173
Brachytrinae, 84
Bracon, 269
Braconidae, 269
Bradina, 432
Bradypsylla echidnae, 384
Brain, 13
Branchial basket, 82
Branching of veins, types of, 23, A9
Brauer, F., 2
Braula caeca, 367
Braxis, 210
Brenthidae, 240
Bridge-vein, 71
Bristle-tails, 46, 49
Bristling, method of, 494
Brontes, 199; *militaris*, 199; head, R25,C
Brontinae, 199
Brown Beetle, N.Z., see *Odontria zealandica*
Brown Lacewings, 317
Brown Snake, parasite of, 383
Bronze Beetle, N.Z., 236
Brood-canal, 250
Brookes, A. E., 188
Broscinae, 191
Bruchidae, 237
Bruchophagus funebris, 276
Bruchus chinensis, 237, R68; *rufimanus*, 237
Brunettia, 350
Brunswick Black, 499
Bryocatus, 243
Bubonic Plague, carrier of, 382
Bucculatrix, 421, 419
Buchananiella, 153
Buffalo-fly, 375
Buffalo-gnats, 355
Bugong Moth, 442
Bugs, 144
Bulla, 63
Bull-dog Ants, see *Myrmecia*
Bunchy-top Disease, 172
Buprestidae, 216
Buprestinae, 218
Burbanga gilmori, 161; pl.12.f.19
Burmeister, H., 403n
Burnet Moths, 435
Burr, M., 108, 111n
Burrower Bugs, 148
Burrowing Wasps, 292
Bursa copulatrix, 38
Burying Beetles, 208
Butterflies, 454, 396
Byrrhidae, 206
Byrrhodes gravidus, 214
Byrrhoidea, 206
Byrsax, 222
Bythoscopinae, 163
Bythoscopus, 163

Cabasa, 362
Cabbage Aphis, 172
Cabbage-Moth, 421
Cabbage Tree (N.Z.), see *Cordyline*
Cabinet-mites, 129, 496
Cabinet points, 493
Cacaecia, 428; *australasiae*, 428
Caccomolpus, 236
Caconeura, 76
Caddis-flies, 385
Cadelle Beetle, 201
Cadira acerella, 433
Cadmus, 235
Caeciliidae, 130
Caecilius, 130; *flavistigma*, wings, N2,C; tarsus, N1,E
Caedicia olivacea, 95; pl.6.f.5
Cafius, 209; *littoreus*, 209; *maritimus*, 209
Calachromus, 213

Calamoceratidae, 392
Calandra granaria, 245; *oryzae*, 245
Calandrinae, 245
Calataria, 98; *terminifera*, 98
Calathusa, 442
Calcager, 376
Caliagrion, 77; *billinghursti*, 77; larva, F11,B
Caliroa limacina, 265, 148
Callicoma serratifolia, insects on, 456
Callidia, 433, 430n
Calliephaltes, see *Ichneumon*, 269
Calligrammatidae, 312
Callimome, 275; *antipodum*, 275
Callimomidae, 275
Callimominae, 275
Callipappus, 173; *australis*, 173; pl.6, f.10; *westwoodi*, 173
Calliphara, 149; *imperialis*, 149
Calliphora, 375; *auronotata*, 375; *erythrocephala*, 375; *oceaniae*, 375; *villosa*, 375
Calliphorinae, 375; parasites of, 277
Calliprason sinclairi, 233; pl.2,f.14
Callipyrga, 234
Callistoleon, 323; *erythrocephalus*, 324; pl.23,f.4; *illustris*, 324
Callus, 21
Calobata, 371
Calodema, 217; *plebeja*, 218; pl.15,f.15; *regalis*, 218; pl.15,f.14
Calodera, 209
Calogramma festiva, 441
Calolampra, 91; *irrorata*, 91; pl.7,f.5, 6
Calomantispa spectabilis, 319
Calomela, 236; *curtisi*, 236
Caloodes, 230; *grayanus*, 230; pl.15, f.20; *mastersi*, 230; pl.15,f.21
Calopompilius, 292; *defensor*, 292; alitrunk, T5
Calopterella, 372
Calopterygidae, 78, 80
Calopteryx, 80n; *virgo*, 80n
Calosoma, 191; *schayeri*, 191
Calotermes, 105
Calotermitidae, 105
Calyptrata, 373
Camel Botfly, 376n
Camera-lucida, 498
Campbellia, 376
Camphor Laurel, insects on, 459, 460
Campodea philpotti, 50, B4
Campodeidae, 50
Campodeiform larvae, 42
Camponotinae, 290
Camponotus, 290; *inflatus*, 290; *intrepidus*, 290; pl.21,f.22; *nigriceps*, 290
Campsomeris anthracina, 294; *ferruginea*, 294; pl.20,f.8; *tasmaniensis*, 294
Camptocladius, 352
Campylinae, 220
Campylomyza, 357
Canada Balsam mounts, 499
Candalides, 466; *xanthospilos*, 466; pl.44,f.15
Cannibal flies, 374
Cantao parentum, 149; pl.11,f.9
Cantharidae, 226, 249
Canthyloscelis, 356; *antennata*, W41
Caper, wild, see *Capparis*
Capillaries, 33
Capitate antenna, 14
Capitellum, 339
Capparis, insects on, 464
Capsidae, 153
Capua, 428; *debiliana*, 428; pl.28,f.48; *isosceiana*, 428; *solana*, 428
Capyella lobulata, 148
Carabid mouth-parts, R2
Carabidae, 191
Carabinae, 191
Caraboid larvae, 42, 183
Caraboidea, 190
Carabs, 191
Carbolic acid, use of, 496
Carbon bisulphide, use of, 496
Cardamyla, 433; *carinentalis*, 433; pl.27,f.23; *didymalis*, 433
Cardiaspis, 171
Cardiastethus, 153
Cardiophorus, 220
Cardiopria, 282
Cardiothorax, 222; *acutangulus*, 222; pl.16,f.16; *foveolus*, 222; *macleayi*, 222
Cardo, 15
Carenum, 191
Carenidium, 191; *spaldingi*, 191; pl.15,f.2
Carls' Fixative, 488
Carobius, 318
Carpenter, G. H., 17
Carpenter-bees, 304
Carpet Moths, 452
Carphurus, 213
Carpophagus banksiae, 235
Carpophilus, 202; *australis*, 202, R28
Carposina, 428; *adreptella*, 428; *smaragdias*, 428
Carposinidae, 428
Carter, H. J., 188
Carthaea saturnioides, 450
Cartons, 495
Case Moths, 435
Cassia, insects on, 464
Cassidinae, 237
Cassinia, insects on, 163, 372
Cassytha, insects on, 442
Castes, 102, 287
Castniidae, 417
Castnioidea, 417
Castor-oil plant, see *Ricinus*
Castulo, 444; *gratiosus*, 444; pl.32,f.22; *nivosus*, 444; pl.33,f.16; *shepherdi*, 444; pl.27,f.29
Casuarina, insects on, 163, 171, 173, 174, 217, 218, 413, 425, 426, 448
Casuarina Hawk-moth, 448
Cat Flea, 384; larva, X3

Cat's Ear, 271
Catacanthus nigripes, 149; pl.11,f.7
Cataclysta, 432
Catadromus elseyi, 191; *lacordairei*, 191, R1; elytron and wing, R3
Catasarcus, 242; *spinipennis*, 242; pl. 19,f.18
Catch, 54
Caterpillars, 404
Catoblemma, 442, 408; *dubia*, 442; pl. 32,f.16
Catocalinae, 443
Catocheilus, 294
Catopsilia, 464; *pomona*, 464; *pyranthe pythias*, 464; pl.33,f.29
Catoptes, 242
Catoryctis, 426; *eugramma*, pl.28,f.39
Caustic potash, use of, 498
Cave Locusts, 89, 96
Cave Weta, labium, A6; maxilla, A5
Cave Wetas, 96
Cavonus, 231
Cebrio, 220; *rubripennis*, 220
Cebrionidae, 220
Cebysa leucoteles, 423; pl.27,f.11
Cecidomyia, 357; *destructor*, 357
Cecidomyiid galls, parasites of, 285
Cecidomyiidae, 357
Cecidomyioidea, 356
Cedar Oil, use of, 498
Celama parvitis, 444
Celloidin, use of, 500
Cells, of wing, 24
Cellules, 24
Celluloid, use of, 491, 499
Cenoloba obliteralis, 430
Census of Insecta, 7
Centrobiella, 279n
Centrocnemis, 352
Cephalelinae, 163
Cephalelus, 163; *hudsoni*, 163, Q25
Cephalodesmus, 228
Cephalopsis titillator, 370n
Cephonodes, 448; *hylas*, 448, Z48
Cephrenes augiades sperthias, 456; pl. 44,f.2; pupa, Z57
Ceraegidion horrens, 234
Cerambycidae, 231
Cerambycinae, 232
Cerambycoidea, 231
Cerapachyinae, 288
Ceraphron, 283; *erythrothorax*, 283
Ceraphronidae, 282
Ceratinidae, 305
Ceratitis capitata, 372
Ceratobaeoides, 283
Ceratobaeus, 283
Ceratocheilus, 348
Ceratoferonia phylarchus, 191; pl.17,f. 4
Ceratognathus, 227
Ceratomyza, 372
Ceratophyllus fasciatus, 384; *gallinae*, 384
Ceratopogon, 352; *molestus*, 352; wing, W28
Ceratopsylla caninae, 384; *reducta*, 384
Ceratopsyllidae, 384
Cerceris, 299; *froggatti*, 299; pl.21, f.25
Cerci, 27
Cercopidae, 162
Cercopis jactator, 162
Ceriodes, 368, 370
Cermatulus nasalis, 148; pl.12,f.10
Cernia, 449, 446n
Ceroplastes ceriferus, 174
Ceroplatinae, 354
Ceroplatus, 354
Cerozodia, 348
Cerura, 446, 405; *australis*, 446; *multipunctata*, 446
Cervical sclerites, 18
Cethosia cydippe chrysippe, 463; pl. 42,f.3
Cetonia, 231; *fasciculata*, 231
Cetoniinae, 231
Ceutorrhynchinae, 245
Chaerocydnus nigrosignatus, 148
Chaerocoris paganus, 149
Chaetocneme, 456
Chaetodacus tryoni, 372, W69
Chaetogaster violacea, 376; pl.25,f.28
Chaetolopha leucophragma, 452; pl. 39,f.22
Chaetotaxy, Diptera, 340; head, W11; thorax, W12; Lepidopterous larvae, 406, Z13; Mecopterous larvae, 329
Chafers, 228; Flower or Rose, 231
Chalastrogastra, 263
Chalaza, 406
Chalcididae, 273
Chalcidinae, 274
Chalcidoidea, 271; antenna, T22
Chalcis, 274n
Chalcodectinae, 274
Chalcodrya, 223; *mollis*, 223; *variegata*, 223; pl.18,f.16
Chalcogonatopus, 285
Chalcophorinae, 218
Chalcoponera, 288; *metallica*, 288, T39
Chalcopterus, 223; *nigritarsis*, 223; *variabilis*, 223
Chalcosiidae, 436
Chalcotaenia, 218
Chalinolobus morio, parasite of, 382
Chaoborus, 352
Chara, 350
Charagia, 413, 414; egg, A18,E; *astathes*, 413; pl.27,f.2; *cyanochlora*, 413; *daphnandae*, 413; *eximia*, wing-coupling, Z6A; *lewini*, 413; *lignivora*, 413; *mirabilis*, 413; *nobilis*, 413; *ramsayi*, 413; *scotti*, 413; *splendens*, 413; pl.27,f.1; *virescens*, 413, Z1
Chasmina, 441
Chasmoptera hutti, 321; pl.22,f.18
Cheese-skipper, 372, 344
Cheiragra, 229
Chelepteryx, 439; *collesi*, 439; pl.37, f.1; *felderi*, 439

Chelisoches, 112; *morio*, 112
Chelisochidae, 112
Cherrus, 242; *ebeninus*, 242
Cherry-tree Borer, 426
Chigoes, 382, 383
Chilo, 433
Chiloxanthus, 154
Chimarrha australica, 391
Chinch Bugs, 146
Chionaspis, 174
Chirida maxima, 237; pl.19 f.2
Chiromyzinae, 360
Chironomidae, 352
Chironomus, 352; *zelandicus*, 352; antenna, W1,B
Chisel, 127
Chitin, 9, 468
Chlamydipteryx, 169
Chlamydopsis, 207; *agilis*, 207; pl.16, f.10
Chlidanotidae, 427
Chloeon viridis, 64
Chlorion, 300; *cognatum*, 300; *fumipenne*, 300; *opulentum*, 300; *saevum*, 300; pl.21,f.28; *vestitum*, 300
Chlorochiton suturalis, 229; pl.2,f.12
Chloroclystis, 452; *fumipalpata*, 452; *laticostata*, 452; *maculata*, 452
Chlorocoma, 451; *cadmaria*, 451; pl. 27,f.36
Chlorocysta, 161
Chloroform, use of, 497, 500
Chlorolestes, 78
Chloropidae, 373
Chlorops, 373
Choleva, 208
Chorda, 401
Chordotonal Organs, 36
Choreutis lampadias, 423; pl.28,f.18
Chorion, 39
Chorionin, 39
Chorismagrion, 78, 70, 477; *risi*, venation, F4,B
Chorista, 331, 475; *australis*, 331; pl. 26,f.1, 2; embryo, A19; head, V1; larva, V5; spiracle, A14; genitalia, V4; pupa, V6; wings, V3
Choristella, 331
Choristhemis, 84
Choristidae, 330
Choristopsylla, 384
Chortoicetes, 98, parasite of, 98; *pusilla*, 98
Chromomaea, 223
Chromis erotus, 448
Chrosis, 220; *barbata*, 220; larva, R51,B
Chrysalis, 406
Chrysauginae, 433
Chrysidea reversa, 286
Chrysididae, 286
Chrysidoidea, 285
Chrysis, 286
Chrysobothrinae, 218
Chrysobothris, 218
Chrysochroinae, 219
Chrysocraspeda aurimargo, 451; pl. 39,f.15
Chrysodema aurofoveata, 218; pl.15, f.17
Chrysolophus spectabilis, 243; larva, R13
Chrysomelidae, 234
Chrysomelinae, 236
Chrysomphalus aurantii, 174
Chrysomyia albiceps, 375
Chrysonoma argutella, 425; pl.28,f.27
Chrysopa, 318; *signata*, 318
Chrysophanus, 466; *boldenarum*, 466; pl.31,f.34; *enysi*, 466; *sallustius*, 466; pl.38,f.28
Chrysophilus aequalis, 358
Chrysopidae, 318
Chrysopogon, 362; *crabroniformis*, 362; pl.20,f.23
Chrysops, 359
Chylific ventricle, 31
Cicada, head, Q1; sound-producing apparatus, Q20; larva, Q21
Cicada-hunters, 298; pl.21,f.23
Cicadas, 160
Cicadellinae, 163
Cicadidae, 160, 408n
Cicadinae, 162
Cicadoidea, 159
Cicindela, 192; *latecincta*, 192; pl.17, f.13; *parryi*, 192; *tuberculata*, 192; *ypsilon*, 192
Cicindelidae, 192
Cigarette, beetle, 215
Ciidae, 202
Ciliate antenna, 14
Cilibe, 222; *opacula*, 222; pl.18,f.10
Cimbicinae, 265
Cimex lectularius, 153
Cimicidae, 153
Cineraria, insects on, 440
Cioninae, 245
Circulatory System, 33
Cirphis unipuncta, 442
Cirphula pyrrhocnemis, 98
Cirrhocrista rauma, 433; pl.33,f.10
Cis, 202
Cisseis, 216; *leucosticta*, 216
Cistelidae, 223
Citrus trees, insects on, 456
Cixiidae, 166
Cizara, 448; *ardenia*, 448; pl.27,f.32
Cladioneura, 130
Cladothrips, 139
Clambus, 208
Clania tenuis, 435; wings, Z34
Clarissa, 265
Clark, J., 262
Clasiopa, 373
Claspers, 28; Diptera, 339; legs, 403; Lepidopterous larvae, 405; Trichoptera, 387
Classification of Orders, 3
Claval suture, 25, 141, 144
Clavate antenna, 14 A4,D
Clavicornia, 195, 199

Clavigerinae, 210
Clavola, 271
Clavus, 25, 141, 144, 158
Claws, 19, D1.C
Clearwing Moths, 424
Cleggs, 358
Clematostigma, 130
Cleonymidae, 276
Cleora, 450n
Clepsicosma, 431
Cleridae, 213
Click Beetles, 219
Clistogastra, 265
Clitarchus, 94
Clitellariinae, 360
Clitumninae, 94
Clivina rugithorax, 191
Cloaca, 403
Clothes-moths, 421
Clothoda, 122
Clove oil, use of, 490
Clypeolus, 127
Clypeorrhynchus, 242
Clypeus, 12
Clytocosmus, 348; *helmsi*, 348; *tillyardi*, 348; pl.20,f.18
Clytrinae, 235
Clytus, 234
Cnethocampinae, 447
Coarctate larva, 226
Coccid Galls, pl.14,f.1-8
Coccidae, 173; enemies of, 373, 423
Coccinae, 174
Coccinella, 205; *tasmani*, 205; *transversalis*, 205; *11-punctata*, 205
Coccinellidae, 204
Coccinellinae, 205
Coccoidea, 172
Coccidoxenus, 277
Coccophagus, 278
Coccus, 174; *hesperidum*, 174; parasite of, 277
Cochlidiidae, 436
Cockchafers, 229
Cocoon, 44
Codling Moth, 427; parasites of, 269, 279, 285
Codula, 362; *vespiformis*, 362; pl.20, f.22
Coelocyba, 277
Coelioxinae, 304
Coelioxys, 304; *albolineata*, 304
Coelopa, 371; *littoralis*, 371
Coelostomidia, 173; *zealandica*, 173; pl.13,f.4
Coelura, 56
Coenagrion, 80n
Coenagriidae, 76
Coenagriinae, 77
Coenagrioidea, 76
Coenoprosopon, 359
Coenosia, 374
Coenotes eremophilae, 448
Coequosa, 448; *australasiae*, 448; pl. 37,f.3; *triangularis*, 448; pl.34; larva, Z47
Coesyra, 425; *dichroella*, 425; pl.27, f.15
Coleophoridae, 426
Coleoptera, 176, 5; Permian, 472; Triassic, 475; male genitalia, R6; mouth-parts, R2; venation, R3-R5
Collecting-tubes, 486
Collection of Insects, 484, 490
Colgar peracuta, 170
Collembola, 53, 3
Colletidae, 302
Collophore, 53
Coloburiscus, 62; *haleuticus*, 62; *humeralis*, 62
Colon, 32
Colpocephalum, 134
Colydiidae, 200
Colydioidea, 199
Commentry fossils, 468
Commius elegans, 148; pl.6,f.12
Comodica, 421; *mystacinella*, 421; *tigrina*, 421; pl.27,f.5
Comocrus behri, 441; pl.36,f.1
Composition of Fossil Insect Faunas, Table, 482
Compound Eye, 34, 13, A15
Compsistis, 425
Comptosia, 364; *fasciipennis*, 364; pl. 25,f.22; *sylvanus*, 364
Comstock, J. H., 22, 23, 25, 58, 89, 114, 338
Comstock and Needham, Venational Notation, 21, 23, 24, 59, 67, 144, 255, 257, 258, 338, 401
Concave veins, 20
Conicera, 366
Coniopterygidae, 320
Coniopterygoidea, 320
Conjunctiva, 10
Conocephalinae, 95
Conopidae, 370
Conops, 370; *pica*, 370
Conosoma, 209
Conostigmus, 283
Convex Veins, 20
Convolvulus Hawk Moth, 447, 448
Copeognatha, 126, 5; head, N1A,B; venation, N1, N2
Copidita, 225
Coppers, 465, 464, 466
Coprinae, 228
Copromorpha, 424
Copromorphidae, 423
Coprosma rigida, insects on, 172
Coptosoma, 149
Coptotermes lacteus, 104, 106; queen, H4
Copulatory aperture, 403
Coralline Seaweed, insects on, 374
Corcyra cephalonica, 434
Cordulegasteridae, 82, 84
Cordulephya, 80, 85; *montana*, 85; pl.5,f.6; *pygmaea*, 85
Corduliidae, 84
Corduliinae, 85
Cordus hospes, 240, pl.16,f.19

Cordyceps, 413
Cordyline, insects on, 174, 452
Cordylura debilis, 371
Cordyluridae, 371
Coreidae, 147
Corethra, 352
Corethrella, 352
Corethrinae, 351
Corium, 141, 144
Corixidae, 158
Corixoidea, 157
Corn Ear Worm, 442
Corn Weevils, 246
Corneagen Cells, 34
Corneal Lens, 13, 34, 36
Cornicles, 171
Corticaria, 204
Corydalidae, 313
Corylophidae, 205
Corylophodes, 205; *nigellus*, 205, R34
Corymbites, 220; *agriotoides*, 220
Corynophyllus, 231
Coryphistes, 98; *ruricola*, 98; pl.7.f. 14
Coscinoscera hercules, 454, 408; frontispiece, pl.1
Cosina, 324; *annulata*, 324; *maclachlani*, 324; *neozelandica*, 324
Cosmodes elegans, 441; pl.32.f.12
Cosmopolites sordida, 245
Cosmopterygidae, 426
Cosmopteryx, 426
Cosmozosteria, 91
Cossidae, 416
Cossinae, 416
Cossodes, 416
Cossoidea, 416
Cossoninae, 246
Cossonus, 246
Costa, 22
Costal series, 24
Costleya discoidea, 229
Costo-radial trachea, 20
Cotachena histricalis, 432
Cotana, 453
Cotes, 224; *punctata*, 224, R54
Cothonaspis, 271
Cotton Boll-worm, 442
Cotton, insects on, 426, 442
Cottony Cushion Scale, 173, 205, see *Icerya purchasi*
Coxa, 19
Coxal cavities, 180, 178
Coxelus, 200
Coxites, 26
Crabronidae, 301
Crabro, 301, *cinctus*, 301
Crambidae, 433
Crambus, 433; *heliotes*, 433; pl.38,f.7; *isochytus*, 433; pl.31.f.12; *malacellus*, 433; pl.33,f.11
Crane-flies, 347
Creiis longipennis, 171; pl.11,f.18
Cremastogaster, 289; *fusca*, 289; *pallipes*, 289
Cremaster, 407
Cremnops, 269; *dissimilis*, 269; pl. 21,f.8; *rufus*, 269
Creophilus erythrocephalus, 209, R40, A
Crepidomenus, 220
Cretaceous period, 477, 478
Crexa, 437
Crickets, 97
Crimson Speckled Moth, 444
Criocerinae, 235
Crocanthes, 426; *sidonia*, pl.28.f.40
Croce attenuata, 321
Crochets, 406
Crocinae, 321
Crocisa, 304; *lamprosoma*, 304, pl. 20,f.14
Crocothemis nigrifrons, 86
Crop, 31
Cross-veins, 24
Craria donovani, 441; pl.32,f.13
Cryphalus, 239
Crypsiphona occultaria, 451; pl.39.f. 11
Cryptes baccatus, 174; galls, pl.14.f. 8
Cryptinae, 269
Cryptocephalinae, 235
Cryptocephalus, 235
Cryptocerata, 154
Cryptochaetum, 373; parasite of, 278
Cryptocheilus, 293
Cryptodachne, 203
Cryptodus, 231; *paradoxus*, 231
Cryptohypnus, 220
Cryptolaemus, 205; *montrouzieri*, 205
Crptolechia, 424; *radiosella*, 424; pl. 28,f.21
Cryptomorpha, 199
Cryptophagidae, 201
Cryptophagus, 202; *globipennis*, 202; *rutilus*, 202, R27
Cryptophasa, 425; *flavolineata*, 425; pl.33.f.4; *irrorata*, 425; *nigricincta*, 425; *nymphidias*, 425; pl.33.f.3; *rubescens*, 425
Cryptopygus niger, 56
Cryptorhynchinae, 245
Cryptothrips, 139
Cryptus, 269
Crystalline Cone, 35
Ctenaphides, 243
Ctenidia, 380
Cteniplectron, 223
Ctenocephalus canis, 384; *felis*, 384 larva, X3
Ctenochiton, 174; *viridis*, 174; pl.13 f.5
Ctenolepisma longicaudata, 49
Ctenoneurus hochstetteri, 150, Q6
Ctenopseustis obliquana, 428; pl.31 f.4
Ctenopsylla musculi, 384
Ctimene, 451; *synestia*, 451; pl.27,f.[illegible]
Cubicorrhynchus, 242
Cubital loop, 130; pecten, 400
Cubito-anal trachea, 20

Cubito-median Y-vein, 23, 400, 410
Cubitus, 22
Cuckoo-bees, 303
Cuckoos, insects attacked by, 440
Cuckoo-spit, 162
Cuckoo-wasps, 286
Cucujidae, 198
Cucujinae, 198
Cucujoidea, 197
Cuculliinae, 442
Cucumber-moth, 432
Culama, 416; *australis*, 416
Culex, 351; *fatigans*, 351; *pervigilans*, 351; antenna, W1.C
Culicidae, 350
Culicinae, 351
Culicoidea, 349
Cuneus, 145, 152
Cup-moths, 436
Cupes varians, 195
Cupha prosope, 463; pl.40.f.11
Cupidae, 194
Cupoidea, 194
Curculionidae, 241
Curculioninae, 243
Curculionoidea, 237
Curicta, 433
Curimus, 206
Curis, 218
Currant Borer, 424
Cursoria, 90
Cuspicona, 149
Cuticle, 9, 30
Cutilia, 91; *sedilloti*, 91; pl.7.f.1
Cybister, 193; *gayndahensis*, 193; pl.17,f.15
Cyclochila australasiae, 162, Q19; sound-producing apparatus, 220
Cyclocranium, 234
Cyclonotum, 197
Cyclopodia pteropus, 378, W72
Cyclorrhapha, 365
Cyclotorna, 422; *egena*, 422; *monocentra*, 422; pl.32,f.1
Cyclotornidae, 422
Cydia pomonella, 427
Cydistomyia, 359
Cydmaea, 243; *luctuosa*, 243
Cydnidae, 148
Cyladinae, 243
Cylas formicarius, 244
Cylindracheta, 97; *kochi*, 97; pl.7,f.12
Cylindrococcus, 174; *spiniferus*, 174; galls, pl.14,f.7
Cylindrorhininae, 242
Cyloma, 197
Cyminae, 147
Cynipidae, 271
Cynipoidea, 270
Cyphagogus, 240
Cyphaleinae, 223
Cyphaleus, 223
Cyphanus, 214
Cyphoderus, 56
Cyphon, 214
Cyphonyx, 293
Cyria, 219; *imperialis*, 219; pl.15.f.16
Cyrioides, 219
Cyrtidae, 360
Cyrtorhinus, 152; *mundulus*, 152
Cystosoma, 161; *saundersi*, 161; pl.12, f.20
Cytherea, 364

Dabra, 209
Dabrosoma, 209
Dacoderinae, 221
Dacryon, 289
Dactylopius, 174; *coccus*, 174; *tomentosus*, 174
Dacus psidii, 372
Daddy-long-legs, 347
Daerlac, 147; *tricolor*, 147; pl.12.f.2
Damsel-flies, 74, 65
Danaida, 461; *archippus*, 461; larva, Z65; pupa, Z66; *chrysippus petilia*, 462; *melissa hamata*, 461; pl.42,f.1
Danainae, 461
Danima, 446; *banksiae*, 446; pl.39,f.2
Darwin, C., 139
Dascillidae, 214
Dascilloidea, 214
Dasyomma, 358
Dasypodia, 443
Dasypogoninae, 362
Dasyproctus, 301
Dasytes, 213; *anachoris*, 213, R44
Dasyuris, 452; *cailicrena*, 452; pl.38, f.17; *hedylepta*, 452; pl.39,f.24; *partheniata*, 452, pl.31,f.26
Dasyurus, parasite of, 384
Daunus, 165
Daveyia mira, 210; pl.16,f.5
David, T. W. E., 470n
Death-watch, Greater, 215
Decatomothorax gallicola, 277
Decilaus, 245
Declana, 451; *atronivea*, 451; pl.33, f.22; *egregia*, 451; pl.33,f.23; *glacialis*, 451; pl.38,f.16
Degeeriella, 134
Degithina, 269
Deilephila gloriosa, 448; *lineata*, 447; *placida*, 448; pl.36,f.5
Deinacrida heteracantha, 97; pl.8,f.1; *rugosa*, 97
Deinelenchus australensis, 251, S5, S6
Delias, 463; parasites of, 274; *aganippe*, 463; pl.44,f.10; *argenthona*, 463; pl.44,f.11; wings, Z69; *harpalyce*, 463; pl.44,f.9; *mysis*, 464; pl.44,f.12; *nigrina*, 463
Deleatidium lillii, 63
Delphacidae, 166
Delphacodes, 166
Delogenes limodoxa, 434
Deltocephalus, 163
Deltoid Moths, 443
Demetrida nasuta, 192; pl.17,f.9
Demonassa macleayi, 234
Demoplatus, 359
Dendrobium, insects on, 235

Dendrocerus, 283
Dendroleontinae, 323
Dendrotrupes, 239
Dengue fever, carrier of, 351
Denmark Hill Fossil Bed, 470n
Dentes, 54
Depressariinae, 424
Derbidae, 166
Deretaphrus, 200; *ignarius*, pl.18.f.3
Dermaptera, 107, 4; parts, J4, J5
Dermatophilidae, 383
Dermatophilus penetrans, 382
Dermestes, 206; *lardarius*, 206; *vulpinus*, 206
Dermestidae, 206
Desudaba, 168; *maculata*, 168; pl.11.f.15; *psittacus*, 168
Deudoryx, 465; *epijarbas diovis*, 465; pl.40,f.5
Deutocerebrum, 13
Devil's Coach-horse, 209
Dexiinae, 376
Diabathriinae, 242
Diadocidinae, 352
Diadoxus, 218
Diagrypnodes wakefieldi, 199, R25.B
Diamma bicolor, 294; pl.20,f.6
Diamminae, 294
Diamond-back Moth, 421
Diamond Weevil, 243
Dianthidium, 304
Diaperinae, 222
Diaphorus, 365
Diaphragm, 33, 34
Diaphramorpha, 235
Diapria coccophaga, 282
Diapriidae, 282
Diaphonia, 231; *dorsalis*, 231
Diapyra igniflua, 424
Diaspinae, 174
Diaspis, 174
Diastamerus tomentosus, 234
Diastata, 372
Diatomineura, see *Osca*
Diceratucha, 446n
Dichaetophora, 371
Dichomeris, 426; *capnites*, 426
Dichoptic eyes, 13, 333
Dichotomic venation, 23, A9,A
Dichrococis punctiferalis, 432
Dichromodes, 449; *confluaria*, 449; pl.39,f.5; *nigra*, 450
Dicky Rice Weevil, 241
Dicrana, 111
Dicraneura, 163
Dicranomyia, 348; *monilicornis*, 348
Dictericophorus, 220
Dictyochrysa, 318; *fulva*, pl.22.f.15
Dictyophoridae, 168
Dictyoptera, 90
Dictyopus, 148; *caenosus*, 148
Didymocantha, 233; *cognata*, 233
Dielis, see *Campsomeris*
Diemeniana, 161
Dieuches, 147
Digging Wasps, 292
Digonochaeta setipennis, 110, 376
Dilaridae, 311
Dilochrosis, 231; *balteata*, 231
Dilophus, 356; *nigrostigma*, W40
Dimera, 128
Dimorphothynnus, 294; *fimbriatus*, 294
Dindymus, 147; *versicolor*, 147
Dingkana, 165
Dinidorinae, 148
Dinotoperla, 119; *carpenteri*, 119, K5; venation, K6; *fasciata*, 119; pl.10, f.13
Dinoura, 276; *auriventris*, 276, T25; *cyanea*, 276
Diochlistus, 363; *aureipennis*, 363; pl.20,f.25
Dioedimorpha wollastoniana, 246, R84
Diopsidae, 371
Diozoceridae, 251
Diphamorphos, 265
Diphlebia, 79; *euphoeoides*, 80; pl.11.f.1; *lestoides*, pl.3,f.6; larva, f.15; venation, f.12
Diplacodes, 86; *bipunctata*, 86; larva, F21.C; *haematodes*, 86; *melanopsis*, 86; pl.4,f.6
Diphobia, 215
Diphucephala, 229; *aurulenta*, 229; *colaspidoides*, 229; *elegans*, 229; *rufipes*, 229
Diphyllocera, 229
Diplocotes, 215
Diploctena argocyma, 452; pl.39,f.25; *nephodes*, 452; pl.39,f.26
Diploptera, 295
Diploptera dytiscoides, 92, G3
Diplosis, 357; wing, W42
Dipsaconia, 222
Diptera, 333, 6; antennae, W1; archaic venational scheme, W8; chaetotaxy, W11, W12; egg, A18,B; Triassic ancestors of, 476
Diptychophora, 433; *interrupta*, 433; pl.38,f.8
Discobola, 348
Discocellulars, 401
Discoelius, 296
Discoidal cell (Odonata), 69; (Diptera), 338n
Discolia, see *Scolia*
Discothyrea, 288
Disogmus, 282
Dissections, 498
Distichocera, 233; *macleayi*, 233
Distypsidera, 192; *undulata*, 192; pl 17, f.14
Ditaxis, 319; *biseriata*, 319; pl.22,f.17
Ditoma, 200
Ditropidus, 235
Dixa, 352; *campbelli*, 352; *tasmaniensis*, 352; wing, W27
Dixidae, 352
Dobson-flies, 313
Dodd, A. P., 230, 283
Dodd, F. P., 422, 454

Dodder, see *Cassytha*
Dodonidia, 455; *helmsi*, 462; pl.38,f.30
Dog Flea, 384
Dohrnia mironda, 225, R56
Doleschallia bisaltide australis, 463; pl.40,f.10
Dolichoderinae, 289
Dolichoderus, 290
Dolichopeza, 348; *cinerea*, 348
Dolichopodidae, 365
Dolichopodinae, 365
Dolophilus michaelseni, 391
Doloplastus, 352
Donuca, 443; *lanipes*, 443; *rubropicta*, 443; pl.35,f.5
Doratifera, 436; *longerans*, 436; *oxleyi*, 436; pl.30,f.17; *vulnerans*, 436; pl.32,f.3; wings, Z35
Dorcadida, 234
Dorsal aorta, 33; diaphragm, 33; trunk trachea, 33
Dorsum, 399
Doru, 112
Doryctomorpha antipodum, 269
Dorylinae, 288
Doticus pestilens, 240
Double Drummer Cicada, 162
Double-headed butterflies, 465; caterpillars, 448, Z47
Double-tailed Emperor, 463
Double-mounting, 491
Dragonflies, 65, 80; egg, A18,A,D; ovipositor, A10
Drapetes vicinus, 219
Drapetis, 365
Drepanacra binocula and varieties, 317; pl.22,f.7-11
Drepanicus, 319
Drepanidae, 439
Drepanodes, 451; *muriferata*, 451; pl. 31,f.24
Drepanomina berothoides, 318; pl.22, f.12
Drepanura, 56
Drone fly, 368
Drosophila, 373
Drosophilidae, 373
Drug-store Beetle, 215
Dryinidae, 285
Drymiarcha, 433
Dryocora, 199; *walkeri*, R25,A
Dryomyza, 371
Dryomyzinae, 371
Dryopidae, 216
Dryopinae, 216
Duadicus, 148; *pallidus*, 148; pl.12,f.8
Duaringa Bore, 479
Dudgeona, 416
Dung Beetles, 228
Dunstan, B., 470n, 474
Dunstaniidae, 143, 475
Duomyia, 371
Dynastinae, 230
Dysarchus, 222
Dysdercus, 147
Dysnocryptus, 240
Dyspessa, 416
Dysthania, 451
Dytiscidae, 192; larva, R7

Earias, 442; *huegeli*, 442; *smaragdina*, 442; pl.27,f.27
Ears, 36
Earwig, European, 110, parasites of, 376
Earwigs, 107
Eaton, A. E., 58
Ecdysis, 9, 41
Echidna, parasites of, 383, 384
Echidnophaga, 383; *ambulans*, 383, X4; *gallinacea*, 382, 383; *liopus*, 383; *macronychia*, 383; *myrmecobii*, 383
Echinophthiriidae, 134
Echinosoma, 111
Echmepteryx hartmeyeri, 129
Echthrodelphax, 285
Echthromorpha intricatoria, 269; pl. 21,f.6
Eclecta aurorella, 425; pl.28,f.32
Ecnomus continentalis, 392
Ecphantus cristatus, 98; *quadrilobus*, 98
Ectatomma, see *Chalcoponera*
Ectatommiphila, 207
Ectenopsis, 339
Ectinorrhynchus variabilis, 362; *vidnus*, 362; pl.25,f.14
Ectobiinae, 91
Ectocemus pterygorrhinus, 240, R73
Ectopsocus, 130; *briggsi*, 130; *congener*, 130
Ectopterygota, 3
Ectotrophica, 49
Ectrephes formicarum, 215; pl.16,f. 15; *kingi*, 215; *pascoei*, 215
Ectrominae, 277
Ectropa, 373
Ectropis camelaria 459; pl.39,f.9
Ectyche, 222
Edwardsia, insects on, 173
Edwardsina, 355; *australiensis*, 355; larva, W15; *confinis*, male genitalia, W9; *tasmaniensis*, antenna, W1,A; mouth-parts, W2; *tillyardi*, W38; pupa, W19
Egg, 39; types of, A18
Egg-capsule, see Ootheca, 89
Eidoleon bistrigatus, 323; *nigrosignatus*, 324
Eidosmylus 320
Einasleigh Hot Springs, 470n
Eiratus, 243
Eirone, 294
Ejaculatory duct, 38
Elachertinae, 278
Elachista, 426; *thallophora*, pl.28,f.42
Elachistidae, 426
Elasmidae, 278
Elasmus, 278
Elassoptila microxutha, 436
Elateridae, 219

Elaterinae, 220
Elateroidea, 215
Elaunon, 112
Elbow-pin mounts, 491, ZB3
Elcanidae, 469, 90, 474
Elcanopsis sydneiensis, 473
Elderberry pith, use of, 498
Elcale, 213
Elenchidae, 251
Elenchoidea, 251
Elenchoides perkinsi, 250
Elephant Beetle, 243; Queensland, 230; New Zealand, 245
Elephantomyia, 348
Eligma, 442; *orthoxantha*, 442
Elimus, 296
Ellipsidion, 91
Elmis, see *Helmis*
Elodina, 464; *egnatia angulipennis*, 464; pl.33,f.28
Elvia, 452; *glaucata*, 452; pl.38,f.26
Elymniinae, 461
Elytron (Coleoptera), 176; (Dermaptera), 108
Embedding, 499
Embiaria, 120, 4
Embolium, 145
Embryo, 40, A19
Embryology, 40
Emenadia, 225
Emeralds, 451
Emesinae, 151
Emmalocera, 434; *latilimbella*, 434; pl.30,f.14
Emperor Butterfly, 463; Moths, 453
Empididae, 365
Empis, 365
Empodium, 19, 336, D1,C
Enamillus, 229; *mauricei*, 229
Enasiba, 215; *tristis*, 215; pl.16,f.12
Encara, 222; *floccosa*, 222
Encryphodes thermochroa, 434
Encyrtidae, 277
Encyrtinae, 277
Encyrtoscelio, 283
Encyrtus, 277; *flavus*, 277; *inquisitor*, 277
End-filament, 38
Endomychidae, 204
Endopterygota, 5
Endoskeleton, 11
Endotricha, 432; *mesenterialis*, 432; pl.30,f.10; *pyrosalis*, 432
Enithares, 157
Enneaphyllus, 232
Entedon metallicus, 278
Entometa, 437; *australasiae*, 437; pl. 30.f.18
Entomobrya, 56; *mawsoni*, 56; D1,A
Entomobryidae, 56
Entomobryinae, 56
Entotrophica, 50
Eocenchrea maorica, 166; pl.12,f.24
Eosentomidae, 52
Eosentomum, 52
Epactiothynnus, 294
Epallagidae, 79
Epermeniidae, 426
Ephedrus persicae, 270
Ephemeridae, 62
Ephemeroptera, see Plectoptera
Ephestia cautella, 434; *kuehniella*, 434
Ephippitytha, 32; *guttata*, 95
Ephutomorpha, 295; *burkei*, 295; *cordata*, 295; *edmondi*, 295; *ferruginata*, 295; pl.21,f.10, 11; *rugicollis*, 295
Ephydra, 373
Ephydridae, 373
Ephygrobia, 373
Epicephala, 422
Epichrysis lamprimoides, 230
Epicoma, 447; *melanospila*, 447; pl 39,f.3; *tristis*, wings, Z45
Epicranial suture, 12
Epicranium, 12
Epicrocis festivella, 434
Epidenocarsis, 277
Epidesma, 451
Epidesmia, 450; *hypenaria*, 450; pl. 39,f.6; *replicatoria*, pl.33,f.20; *tricolor*, 450
Epidosis, 357
Epigonatopus, 285
Epilachna, 295; *guttato-pustulata*, 205; *28-punctata*, 205
Epilachninae, 205
Epilamprinae, 91
Epimeron, 18
Epiophlebia, 74
Epipaschia, 432; *semnivea*, 432
Epipharynx, 15
Epiphthora, 426
Epiplema, 444; *instabilata*, 444; pl. 33,f.18
Epiplemidae, 444
Epipyropidae, 422
Epipyrops, 422
Epirrhanthis alectoraria, 450
Epirrhoeca, 427
Episcaphula, 203; *australis*, 203; *hercules*, 203; *nigrofasciata*, 203; pl 15,f.4; *pictipennis*, 203
Episphaenoides, 226; *capitalis*, 227
Episternum, 18
Epopostruma, 289
Epuraea, 202
Erana graminosa, 442; pl.38,f.12
Erastriinae, 442
Erebia, 455; *butleri*, 463; pl.31,f.32 egg, A18,F; *merula*, 463; pl.31, 31; *pluto*, 463
Erebiola, see *Erebia*
Erecthias, 421
Eremophila, insects on, 448
Eremochroa, 441
Erephopsis, 359; *adrel*, 359; *guttat* 359; pl.25,f.7
Eretes australis, 193, R19
Eretmocera, 423
Ericmodes australis, 202

Eriocampoides, see *Caliroa*
Eriococcus coriaceus, 174, 205; pl.13, f.2, 3
Eriocraniidae, 412, 412n
Eriodyta, 425; *contentella*, pl.28,f.30
Eriopterinae, 348
Erirhininae, 243
Erirhinus, 243
Eristalis, 368; *decorus*, 368; *pulchellus*, 368; pl.20,f.26; *punctulatus*, 368; *tenax*, 368
Erotylidae, 203
Eruciform larvae, 42
Erwinea amylovora, carrier of, 170
Erynninae, 456
Erythroneura, 163
Escala, 91; *circumducta*, 91
Eschatura femurias, 420; pl.33,f.5
Esdaile, T., 469
Estheria, 477
Estigmene, 444; *interfixa*, 444; pl.32, f.24
Etheridge, R., 474, 479
Ethmia, 422
Ethon, 216
Ethyl acetate, use of, 488
Etiella walsinghamiella, 434
Euamphibolia, 376; *fulvipes*, 376; pl. 25,f.27
Euboriella, 111; *tasmanica*, 111
Eucallionyma sarcodes, 434
Eucalymnatus tesselatus, 174
Eucalyptus, insects on, 94, 164, 168, 170, 171, 173, 174, 205, 229, 230, 232, 233, 236, 242, 265, 276, 278, 315, 320, 322, 357, 358, 413, 417, 424, 425, 436, 439, 448, 454; collecting at, 488; *corymbosa*, insects on, 278; galls of, 357; *globulus*, insects on, 233, 242; galls, 278
Eucarteria floralis, 227
Eucerocoris, 152
Eucharis, 275
Eucharitidae, 274
Euchroma, 444
Euchrysia, 274
Euclarkia, 200
Eucleidae, 436
Euclimacia, 319
Eucnemidae, 219
Eucoelia gracilicornis, 271
Eucolaspis, 235; *brunneus*, 236; *ochraceus*, 236
Eucone, 35
Eucosma plebeiana, 427
Eucosmidae, 427
Eucossonus, 246
Eucyclodes pieroides, 451; female, pl.39,f.13; male, pl.33,f.24; *metaspila*, larva, Z51
Eudermaptera, 112, 111n
Eudyptula minor, parasite of, 384
Eufairmairea, 165; *fraterna*, 165; pl.11,f.14
Eufroggattia, 165
Eugnomus, 243
Euhoplopria, 282
Eulechrio, 424; *triferella*; pl.28,f.23
Eulechriinae, 424
Eulepis pyrrhus sempronius, 463; pl. 42,f.4
Eulophidae, 278
Euloxia, 451; *gratiosata*, 451; pl.39, f.12; *meandraria*, 451; pl.27,f.35
Eumecoptera, 330
Eumecopus, 148; *australasiae*, 148
Eumenes, 296; *arcuatus*, 296; *latreilli*, 296; pl.20,f.11; larva, T12
Eumenidae, 295
Eumeninae, 295
Eumolpinae, 235
Eunotoperla kershawi, 119; pl.10,f.16
Euodia accedens, insects on, 459
Euophryum, 246
Euops, 243
Euosmylus stellae, 320; pl.2,f.21; larva, U4
Euparagia, 296; *bidens*, 296; *deceptor*, 296; pl.21,f.14; *decipiens*, 296
Eupatorus australicus, 230
Eupelminae, 277
Eupelmus, 277; *messene*, 277
Euphalia pardalis, 242
Euphanta, 169
Euphyia, 452; *chrysocyma*, 452; pl. 39,f.16; *deltoidata*, wings, Z50; *oxygona*, 452; pl.39,f.18; *perornata*, 452; pl.27,f.38; *polycarpa*, 452; pl.39,f.17; *purpurifera*, 452; pl.31, f.27; *stereozona*, 452; pl.39,f.19
Euphyurus, 64
Eupines, 210
Euplectops, 210
Euplectus, 210
Euploea, 461; *corinna*, 461, Z5
Eupoecila australasiae, 231; pl.15,f. 23; *inscripta*, 231
Euponera, 288
Euporismites balli, 479
Euporismus albatrox, 320; pl.24,f 2
Euproctis, 440
Euprosopia tenuicornis, 371; pl.25,f. 25
Eupsalis, 240
Eupselia, 424, 419n
Eupsenella, 285
Eupsocida, 129
Eupterote, 453; *expansa*, 453
Eurhamphus fasciculatus, 243; pl.19, f 20
Eurhynchinae, 243
Eurhynchus, 243
Eurinopsyche doddi, 168; pl.12,f.25
Eurinoscopus, 163
Eurispa, 237; *vittata*, 237; pl.19,f.3
European Rat Flea, 382, 384
Eurybrachidae, 168; parasites of, 251
Eurybrachys, 168
Eurybrochis, 152
Eurycus, 458; *cressida*, 460; pupa, Z62

Euryglossa, 303; *chalcosoma* 303; *crabronica*, 303
Euryischia lestophoni, 278
Eurymela, 164; *bicolor*, 164; *distincta*, 164; *rubrovittata*, 164; pl.11.f.13
Eurymeloides, 164; *pulchra*, 165; pl. 12.f.22
Eurymelops, 164
Eurynassa odewahni, 232
Eurys, 265
Euryscaphus, 191; *waterhousei*, 191; pl.17.f.1
Eurystheus dilatus, 168
Eurythecta, 428
Eurytoma, 276, 284; *acaciae*, 276; *picus*, 276; *oleariae*, 276n
Eurytomidae, 276
Euscelis, 163
Euschemon, 415, 454; *rafflesia*, 455, 408; pl.40.f.1; larva, Z55; pupa, Z56; wings, Z54
Euschemoninae, 455
Eusphinctus, 288
Eusternum, 19
Eusthenia, 117; *lacustris*, 117; pl.11. f.5; male genitalia, K1,B; *lunulata*, 117; pl.10.f.7; *spectabilis*, 117, K1,A; larva, K2
Eustheniidae, 117
Eusthenioidea, 117
Eustheniopsis, 117; *venosa* 118; pl. 10.f.8
Eusynthemis, 84
Euteliinae, 442
Eutermes, 106, 222; *palmerstoni*, 106, 102; *termitarium*, pl.9.f.1; *vernoni*, nasute soldier, H2
Eutermiphora abdominalis, 366
Euthesaura, 430; *carbonaria*, 430; pl. 28.f.53
Euthrausta, 430
Euthrips nervosus, 139
Euthyrrhinus, 245
Eutorna, 424
Eutryona monstrifera, 165
Evania, 268; *appendigaster*, 268; *longigena*, 268
Evaniidae, 268
Evaniinae, 268
Eversible sacs, 26
Excretory Organs, 32; System, 30
Exeiridae, 298
Exeirus lateritius, 298, T2; pl.21 f. 23; pupa, T13
Exeretoneura, 361, 358
Exeristes, 269
Exilis, 240
Exocarpus, insects on, 425, 463
Exochilum, 269; *scaposum*, 269
Exoclaenoides cinctus, 273; pl.21.f.0
Exomatocca nycteris, 456, 455
Exoneura, 305; *bicolor*, 305
Exoprosopa, 364
Exsertile vesicles, 48
Extatosoma tiaratum, 94, G6
External Morphology, 9
Exul singularis, 374; pl.2.f.29; eye, compound, A15

Fairy-flies, 279
Fannia canicularis, 374
Fat-body, 33
Feather-horned Beetles, 213
Femur, 19
Fenestrae, 91
Fenestrate membrane, 35
Fern-frond, mimics of, 451
Fern-weevils, 242
Ferreola collaris, 293
Fhogra, 269
Fibula, 401, 309
Ficus, insects on, 423, 426, 461; *macrophyllia*, insects on, 276
Fiddler Beetle, 231
Fiddler Cicada, 162
Field-work, 484
Fig, Moreton Bay, 276; Smyrna, 276
Figitidae, 271
Figs, see *Ficus*
Fig-trees, collecting at, 489
Filiform antenna, 14, A4,B
Filter, 158
Fingulus regularis, 227
Finlaya, see *Aedes*
Fire-beetle, 218
Fireblight, 170
Fireflies, 212
Firewood Beetles, 233
Fish-killer, Giant, 157
Fissicorn Tachinids, 376
Five-finger, see *Nothopanax*
Five-plume Moths, 428
Fixatives, 488
Flabellate antenna, 15
Flagellum, 14
Flat Bugs, 149
Flatidae, 169
Flax Moth, New Zealand, pl.33.f.26
Fleas, 380, 384; head, X2
Flea Beetles, 236
Flesh-flies, 375
Flies, 333
Flinders River Beds, 477
Flour Beetles, 223; Moth, Mediterranean, 434
Floury Miller, 161
Flower-blossoms, collecting at, 488
Flower Bugs, 153; chafers, 231; wasps, 293; hairy do., 294
Fluted Papilios, 459
Fluted Scale, 173
Fly-fishing, 61
Foenus, see *Gasteruption*
Follicles, 38
Footmen Moths, 444
Forceps, Insect, 486
Foregut, 31
Forest-floor, Collecting, 486
Forester Moths, 435
Forficula auricularia, 110, 112; parasites of, 376
Forficulidae, 112

Forficuloidea, 112
Formicaleo, 323; *brevinsculus*, 323; *canifrons*, 323; *vafer*, 323
Formicicomus, 234
Formicidae, 287
Formicinae, 290
Formicoidea, 286
Formicomus, 223
Formosina, 373
Fossil Insects, 468; table of, 481
Fossores, 292
Four-plume Moth, 430
Fowl Flea, 384
Frankliniella, 139; *tritici*, 139
Fraudator perspicuus, 365, 364
Fraus, see *Hectomanes*
Frenate coupling, 402
Frenchia, 173
Frenular bristles (Mecoptera), V3
Frenulum, 402, (Hemerobiidae) U10, (Lepidoptera) Z6,B, C
Fritillaries, 463
Frog, fly parasite of, 373
Froggatt, J. L., 245
Froggatt, W. W., 147, 275
Froggattella, 290
Froggattia, 98n; *clivina*, 152, Q9
Froggattina australis, 98
Froggattisca pulchella 323
Frog-hoppers, 162
Frons, 12
Frontal lunule, 334; pl.12
Fruit Bugs, 147
Fruit-flies, 272
Fuchsia, insects on, 479; *excorticata*, insects on, 171
Fulgoridae, 168
Fulgoridicida, 277
Fulgoroidea, 165; parasites of, 285, 367, 422
Fungus Beetles, 203; bugs, 149; gnats, 352
Funicle, 238
Furca, 11
Furniture Borer, 215

Gad-flies, 358
Gadirtha, 442
Gaeana, 162
Gaeaninae, 162
Gahnia, insects on, 147, 462
Galea, 15
Galerucinae, 236
Galgulidae, 156
Galleria mellonella, 434
Galleriidae, 433
Gall-gnats, 357
Gallio australiae, 219
Galls, coccid, pl.14,f.1-8
Gall-wasps, 270, T21
Gardena, 151
Gaster, 287, 254
Gasteruption, 268
Gastric caeca, 31
Gastridiota, 453, 415n
Gastrophilus equi, 376; *intestinalis*, 376; *nasalis*, 376; *veterinus*, 376
Gastrophora henricaria 450; pl.35,f.8
Gastropsis, 302; *pubescens*, 302
Gelastissus, 169
Gelastocoridae, 156
Gelechia, 426
Gelechiidae, 426
Gelis, see *Pesomachus*
Gelophaula, 428; *siraea*, 428; pl.38,f.5
Genae, 12
Genital segments, 26; table of, 28
Geochus, 245; *inaequalis*, R80
Geometers, 445, 405
Geometridae, 451
Geometrites, 449
Geomyzidae, 372
Georyssidae, 203
Georyssus, 203
Geotomus, 148
Geotrupinae, 229
Gephyroneura, 439
Gerallus, 210
Geraniums, insects on, 441
Geranomyia, 348
Germarica, 217
Geron australis, 364
Gerridae, 153
Gerrinae, 153
Gerris, 153; *australis*, 153
Gerroidea, 153
Gigadema maxillaris, 191; pl.17,f.11
Gills, 60, 74, 82, 116
Ginglymus joint, 15
Giraffe Beetle, New Zealand, see *Lasiorrhynchus barbicornis*, 240
Girault, A. A., 262, 271, 276, 278
Gizzard, 31
Glaucias amyoti, 148
Glazed eye, 407
Glenea picta, 234; pl.15,f.27
Glenlee fossil beds, 477
Glenoleon, 323; *falsus*, 323; pl.24,f.4; *meteoricus*, 323; *pulchellus*, 323
Gliricola porcelli, 134
Globular Spring-tails, 56
Glochinorrhinus, 245
Glossa, 17
Glossina, 365n
Glossopteris, 470, 473
Glow-worms, 352, 212, 213; parasites of, 282
Glow-worm Cave, Waitomo, 352
Glycerine, use of, 408; jelly, 499, 500
Glyphipterygidae, 422
Glyphipteryx, 422; mimics of, 421; *zelota*, 423; pl.28,f.17
Glyptoma kingi, 210
Gminatus, 150; *australis*, 150
Gnamptoloma, 451
Gnathocerus cornutus, 223
Gnathos, 403
Gnathoxys, 191
Gnats, 352
Goetymes, 226
Gold Beetles, 227
Golden-eyes, 318
Gold-tail Moth, 440

Gold-wasps, 286
Gomphidae, 83
Gomphocarpus fruticosus, insects on, 462
Gonad, 37
Gonapophyses, 26
Gonatocerus, 280; *spinozai*, 280
Goniaea, 98; *australasiae*, 98; pl.7, f.13
Gondwanaland, 473
Goniodes, 134
Goniozus, 285; *antipodum*, 285
Gonipsyllus kerguelensis, 384
Gonipterinae, 242
Gonipterus, 242; *reticulatus*, 242
Gonochrysis, 286
Gonocoxites, 27
Gonoducts, 37
Gonolabis, 111
Gonopore, 26, 38
Goodna Tertiary fossil beds, 470
Gorytes, see *Arpactus*, 299
Gorytidae, 299
Goshawk, parasite of, 377
Gracilaria, 421, *chrysitis*, 422; pl.28, f.14; *selenitis*, 422; *xanthophorella*, 421
Gracilariidae, 421
Grain Weevil, 245
Grape-vines, insects on, 172, 427, 441
Graphosomatinae, 149
Grass-grubs, 229, 413
Grass-hoppers, 97
Grass-moths, 433
Grass-trees, see *Xanthorrhoea*
Grease, 497
Great Australian Cicada-hunter, 298
Greater Death-watch, 215
Green Mantis, 93, A1
Green Monday Cicada, 162, Q19
Green Tree-ant, 290
Green-bottles, 375
Green-head ant, 288, T39
Greenhouse White-fly, 172
Green Lacewings, 318
Gressoria, 90
Grevillea robusta, insects on, 428
Greyback Sugar-cane Beetle, 230
Ground Beetles, 191
Gryllacrinae, 95
Gryllidae, 97
Grylloblatta campodeiformis, 90
Grylloblattoidea, 90
Gryllotalpa coarctata, 97, pl.7, f.11
Gryllotalpidae, 97
Gryllus servillei, 97; pl.7, f.10
Gryonella, 283
Gular plate, 12, 177, 189
Gum-tree Bugs, 147
Gymnobathra, 425; *flavidella*, 425; pl. 28, f.36
Gymnocerata, 145
Gymnopa, 373
Gynacantha, 84
Gynoplistia, 348; *bella*, 348; pl.20, f.17; *cupraea*, 348; *formosa*, 348
Gyrinidae, 193
Gyrinoidea, 193
Gyrinus huttoni, 194
Gyrophaena, 209
Gyropidae, 134
Gyropus ovalis, 134

Habrolepis dalmanni, 278
Hacker, H., 262
Hadronotus, 283
Haematopinidae, 135
Haematopinus asini, 135; *eurysternus*, 135; *suis*, 135; *tuberculatus*, 135
Haemocoele, 33
Haemodipsus ventricosus, 135
Hahnia australis, 148; pl.12, f.7
Hairs, tactile, 37
Hairstreaks, 465, 464
Hairy Flower-wasps, 294
Hakea, insects on, 446
Hale, H. M., 158
Halictinae, 303
Halictophagidae, 251
Halictophagoidea, 251
Halictus, 303
Haliplidae, 192
Haliplus, 192
Halobates whiteleggi, 153
Halobatinae, 153
Halone sinuata, 444; pl.32, f.23
Halorhynchus caecus, 246; *geniculatus*, 246
Halter, 339, 333
Halticinae, 236
Ham Beetle, 213
Hamitermes, 106; *meridionalis*, 106; termitarium, pl.9.f.4; *silvestrii*, 106; castes, H1; termitarium, pl.9.f.3; *wilsoni*, termitaria, pl.9.f.2
Hamotulus robustus, 210, R41
Hamuli, 255
Handlirsch, A., 2, 87
Hansen, H. J., 17
Haplonycha, 229
Haplonychinae, 235
Haplonyx, 245
Haploscapanes barbarossa, 230
Haplothrips, 139
Hard Scales, 174
Hardy, G. H., 363
Harmolita, 276
Harmologa, 428; *amplexana* 428; pl. 28.f.49; *sanguinea*, 428; pl.38, f.4; pl.48, f.50
Harmomyia omalanthi, 357
Harrison, L., 131, 134
Harpactorinae, 150
Harpactophilus, 300; *steindachneri*, 300
Harpes, 403
Harpobittacus, 332; *australis*, 332; *tillyardi*, 332; pl.26.f.3; mouth-parts, A3
Hasora hasla, 456
Haustellum, 396, 397
Havinthus, 150; *rufovarius*, 150; pl. 11, f.10

Hawk Moths, 447
Head, 12, 9; morphology, A2
Head-capsule, 10
Hearing, Organs of, 36
Heart, 33, A13
Hebridae, 153
Hebrus axillaris, 153
Hecatesia fenestrata, 441; pl.27,f.28
Hectarthrum brevifossum, 198; pl.17, f.20
Hectomanes, 413; *crocea*, 413; *fusca*, 413
Helaeinae, 222
Helaeus, 222; *brevicostatus*, 222; pl 18,f.12
Helcogaster, 213
Helconinae, 269
Helenotus, 150
Helicoconis, 320
Helicopsyche, 395; *albescens*, 395; larva, Y5; case, Y6; *zelandica*, 395
Helina, 374
Heliocharidae, 79
Heliocosma incongruana, 428
Heliodinidae, 423
Heliostibes, 423; *electrica*, 423; pl. 28,f.19
Heliothela, 431; *ophideres*, 431
Heliothis obsoleta, 442
Heliothrips, 139; *haemorrhoidalis*, 139
Helle longirostris, 360
Helluo costatus, 191
Helluoninae, 191
Helminae, 216
Helmis tasmanicus, 216, R47
Helomyza, 371
Helomyzidae, 371
Helophilus, 368; *antipodum*, 368; pl. 2,f.27; *trilineatus*, 368
Heloridae, 280
Helosciomyza, 371
Hemerobiidae, 317
Hemerobiinae, 318
Hemerobioidea, 314
Hemerodromia, 365
Hemicordulia, 84, 85; *australiae*, 85; *superba*, 85; *tau*, 85; larva, F21,B
Hemideina megacephala, 97; pl.8,f.2; head, A2
Hemidoecus leai, 156
Hemielytron, 144
Hemigomphus, 83; *heteroclitus*, 83; pl.5,f.1; venation, F17
Hemilexis, 282
Hemimerina, 110
Hemimerus, 110, 108
Hemimetabola, 3
Hemipeplinae, 199
Hemiphlebia, 69, 70, 78, 477; *mirabilis*, 76; venation, F4,C
Hemiphlebiidae, 76
Hemipipsis, 293
Hemiptera, 140, 5; head, Q1; hemielytron, Q2; Triassic, 474
Hemirhipinae, 220
Hemistephanus, 268
Hemiteles, 269
Hemitergites, 122
Hemithynnus, 294; *inconstans*, 294; *rufiventris*, 294
Henicocephalidae, 151
Henicocephalus, 151; *maclachlani*, 151; *tasmanicus* 151
Henicopsaltria, 162; *eydouxi*, 162; *fullo*, 162; pl.12,f.21
Henicospilus, 269; *turneri*, 269
Hepatic caeca, 31
Hepialidae, 413; parasites of, 434
Hepialoidea, 412
Hepialus, 413
Heptachrysis, 286
Heptagenia, 59
Herina, 371
Hermatobates haddoni, 153
Hermetiinae, 360
Hesperiidae, 455
Hesperiinae, 456
Hesperilla, 457; *idothea*, 457; pl.44, f.4; *ornata*, 457; *picta*, 457; pl.44, f.5, pupa, Z58
Hesperioidea, 455
Hesperocordulia, 80; *berthoudi*, 85; pl.5,f.5
Hessian Fly, 357; parasites of, 278
Hesthesis, 234; *cingulata*, 234; *ferruginea*, 234; pl.15,f.25
Hestiochora tricolor, 435; pl.28,f.57
Heteriptolis, 419n
Heterithone, 314; *megacerca*, 314
Heteroceridae, 204
Heterocera, 415
Heterocerus, 320; *flindersi*, 204, R31
Heterodoxus, 134
Heterogeneidae, 436
Heterognathus geniculatus, 209; pl. 16,f.7
Heterogyna, 286
Heterojapyx, 48; *gallardi*, 51, B2; *victoriae*, 51
Heterolepisma, 49
Heteromastix, 212
Heteromera, 220
Heterometopia argentea, 376
Heteromicta, 433; *latro*, 434; *tripartitella*, 434; pl.30,f.13
Heteroneura, 414
Heteroneuridae, 371
Heteronympha, 462, 455, 463; *banksi*, 462; pl.43,f.4; *merope*, 462; pl.43,f. 1, 2; *mirifica*, 462, pl.43,f.5; *philerope*, 462; pl.43,f.3
Heteronyx, 229; *jubatus*, 229
Heteroptera, 144; Triassic, 474
Hexachrysis, 286; *lyncea*, 286; *tasmanica*, 286; *violacea*, 286
Hexaplocotes sulcifrons, 216; pl.16,f. 13
Hexatricha pulverulenta, 234
Hexham Grey Mosquito, 351
Hibiscus, insects on, 426
Hilara, 365; *flavinceris*, 365, W56
Hindgut, 32
Hippoboscidae, 377
Hippoboscoidea, 377

Hippotion, 448; *brennus johanna*, 449; pl.36,f.7; *celerio* 447; wings, Z46; *scrofa*, 448; pl.36,f.6; wing-coupling, Z6B, C
Hispinae, 237
Histeridae, 206
Histeroidea, 206
Histolysis, 343
Hockings, H. J. 305
Hoheria populnea, insects on, 423
Holacanthella spinosa, 56, D2
Holochrysis, 286
Hololepta, 207; *sidnensis*, 207; pl.18, f.1
Holometabola, 5
Holoptic eyes, 13, 333
Holoptilinae, 151
Holorusia, 348
Homaliinae, 210
Homalium, 210; *longiceps*, head, R40, B
Homocosoma vagella, 434
Homolota, 209
Homona simulana, 428
Homoneura, 410
Homoptera, 158; fossil, 408n, parasites of, 422; Permian, 471; Triassic, 473
Honey, 262, 301
Honey-bees, 301, 305; native, 305, T53
Honey-dew, 172
Honey-pot Ants, 290
Hook-tip Lacewing, 317
Hook-tip Moths, 439
Hoplitis, 446; *cydista*, 447; pl.35,f.7
Hoplobates, 153
Hoplocnemia, 448
Hoplogonus simsoni, 227, R58
Hoplogryon, 283; *novae-zealandiae*, 283
Hoplopria, 282
Hoplostines viridipennis, 236
Haplotelcia, 283
Hormocerus fossulatus, 241
Hornet, 296
Hornfly, 375
Horntails, 263; fossil, 262
Horse-flies, 358
House-fly, 375; parasite of, 277
Hover-flies, 368
Huberia, 289
Hudsonia heterogama 349
Human Flea, 384
Humble-bees, 305
Humeral margin, 179; veinlet, 24
Humming-bird Hawk-moth, 448
Hungerford, H. B., 158
Huphina, 464
Huttonomyia, 371; *scutellata*, W68
Hu-hu, 232
Hyadina, 373
Hyalarcta hubneri, 435
Hyalobathra, 432; *miniosalis*, 432; *pl.27,f.21*
Hybernia, 451
Hyblaea, 441; *constellata*, 441; pl.32, f.8; *ibidias*, 441; pl.32,f.9
Hyblaeinae, 441
Hyborrhynchus, 242
Hydara, 216
Hydrellia, 373
Hydreuretis tullialis, 432
Hydriomena, see *Euphyia*, 452
Hydriomenidae, 452
Hydrobiosella, 391
Hydrobiosis stigma, 391; *umbripennis*, 391; pl.26,f.4; pupa, Y10; wings and details, Y1,A,B
Hydrobius zelandicus, 197
Hydrochorema, 391
Hydrometra strigosa, 153, Q13
Hydrometridae, 153
Hydromys chrysogaster, parasites of, 135
Hydrophilidae, 197
Hydrophiloidea, 197
Hydrophilus, 197, 472; *albipes*, R24; *laticostatus*, elytron, R18; *latipalpus*, 197; pl.17,f.22
Hydrophorinae, 365
Hydrophorus, 365
Hydropsyche, 392; *colonica*, 392; pl. 26,f.8; larva, Y3; house, Y4
Hydropsychidae, 391
Hydroptilidae, 393
Hydroptiloidea, 393
Hygrobia, 192
Hygrobiidae, 192
Hylaeidae, 302
Hylaeoides concinna, 303
Hylaeus, 303; *capitosus*, 303, T50; mouth-parts, T3,D,E; *cognatus*, 303; pl.20,f.13
Hylecoetus, 213; *pervagus*, 213; pl.18, f.8
Hyleora, 446; *dilucida*, 446
Hylesinus, 239
Hylobia, 223
Hylobiinae, 243
Hymenoptera, 252, 6; larva, 260; mouth-parts, T3
Hymenoptychis, 432
Hymenia fascialis, 432; *perspectalis*, 432
Hypandrium, 27
Hypeninae, 443
Hypenodes, 443; *anticlina*, 443; pl.31, f.21; head, Z43; *costistrigalis*, 443
Hyperalonia, 364; *bombyliformis*, 364; pl.25,f.21
Hyperetes australicus, 129
Hyperion schroetteri, 191; pl.17,f.7
Hypermetamorphosis, 42, 183, 226
Hyperomma, 210
Hypertropha tortriciformis, 423; pl. 27,f.12
Hypocera, 366
Hypochaeris radicata, galls on, 371
Hypocisseis, 216; *latipennis*, 217
Hypocysta, 462; *adiante*, 462; *euphemia*, 462; pl.43,f.10; *metirius*, 462; *pseudirius*, 462
Hypodermis, 9, 30
Hypodiranchis aphidis, 271

Hypographa, 449, 446n
Hypolimnas bolina nerina, 463; pl.42, f.2
Hypolycaena, 465
Hypomorphus melanosomus, 245
Hyponomeuta, 422; *myriosemus*, 422; pl.33,f.2
Hyponomeutidae, 422
Hypopharynx, 17, A7
Hypopleural bristles 373
Hypopleuron (Diptera), 336
Hypopygium, 339, W9, 10
Hypostigmatic cell, 321, 322, 323
Hypostigmodera variegata, 216
Hypsa plagiata, 440; pl.35,f.3
Hypsidae, 439
Hypsidea erythropsalis 433, 408
Hypsopygia, 433
Hyptiogaster macrononyx, 268; pl.21, f.4
Hystricia, 376; *lupina* 376; pl.2,f.31

Ialmenus evagoras, 465, pl.44,f.14; wings, Z70
Ibaliidae, 270
Icaria, see *Ropalidia*, 296
Icerya purchasi, 173, 205; pl.13,f.1; parasite of, 278
Ichneumon, 269; *albopictus*, 269; *huttoni*, 269; *messor*, 269
Ichneuman-flies, 268
Ichneumonidae, 268
Ichneumoninae, 269
Ichneumonoidea, 266
Ichneutica, 442; *ceraunias*, 442; pl.38, f.11; *dione*, 442; pl.31,f.19
Ichthybotus, 63, 61; *bicolor*, 62; *hudsoni*, 62; larva, E4; venation, E5
Ictinus, 83; *australis* 83; pl.5,f.2
Idarninae, 275
Idiocerus, 163
Idiococcinae, 174
Idiodes apicata, 450; pl.39,f.10
Idocorduliinae, 84
Idolothrips spectrum, 139; P1
Ileum, 32
Illaphanus, 192; *macleayi*, 192; *stephensi*, 192; pl.16,f.1
Ilema, 444
Illingworth, J. F., 230, 378
Imaginal buds, 44, 343
Imago, 44, 61
Imma, 423, *cleis*, 423
Inaequipalpia, 397
Indian Meal Moth, 434
Indian Rat Flea, 382, 384
Indian Wax Scale, 174; spread by ants, 289
Inglesia, 174
Inner lobe (maxilla), 15
Inopeplus dimidiatus, 199
Inophlaeus, 242
Inquilines, 184, 489
Instar, 9, 41
Internal lobe of labium, 17
Internal morphology, 30
Internal Sac, Coleoptera, 182
Intervals, 179, 473
Intestine, large, 32, small, 32
Intima, of trachea, 33
Ionthocerus, 240
Iphaulax, 269; *rubriceps*, 269
Iphierga euphragma 421; pl.28,f.7
Ipidae, 238
Ipo, 163
Ipomaea, insects on, 449
Ipsaphes, 190; *bicolor*, 190; pl.17,f.19; larva, R9; *mocrosus*, 190
Ipsichora, 245
Ipsvicia jonesi, ZA7
Ipsviciidae, 143, 475
Ipswich Upper Triassic Fossil Beds, 473; table, 487
Iridomyrmex, 289, 215, *detectus*, 289; *rufoniger*, 289; insects in nests of, 466
Ironomyia, 366
Iropoca, 441; *rotundata*, 441; pl.30,f.23
Ischnocera, 134
Ischnoderus, 210
Ischnoptera, 91; *australis*, 91, G1
Ischnotoma serricornis, 348
Ischnura, 77; *aurora*, 77; *heterosticta*, 77
Ismeninae, 456
Isoderminae, 150
Isodermus planus 150; *vacillans*, 150
Isonomeutis, 424
Isoplastus, 352
Isoptera, 100, 4; castes, H1, H2, H4
Isorhynchinae, 245
Isosoma, see *Harmolita*, 276
Isosticta simplex, 76; larva, F11,A
Issidae, 169
Issus, 169
Ithone fusca, 314; pl.22,f.2, 3, larva and pupa, U7
Ithonidae, 314, 230
Ithonoidea, 314
Ithystenus hollandiae, 240
Ittootoonee, 290
Izatha peroneanella, 425; pl.38,f.3

Jack, R. L., 477
Japygidae, 51
Japyx, 51
Jassidae, 163; parasites of, 284, 285, 367, 422
Jassinae, 163
Jewel Beetles, 216
Johannica, 236
Johnston's Organ, 35, 14, 329
Joint, 11
Jugal lobe, 309, 386, 401
Jugum, 401
Julodimorpha, 218
Jumper Ants, 287; pl.21,f.20
Jumping Plant-lice, 170
Jurassic Period, 477
Jurine, L., 255
Jurinian System, 257 258
Juxta, 403

Kangaroo Beetle, 235
Kansas Permian Fossils, 468
Karbi, 305
Katianna, 56
Kawakawa, insects on, 443
Kelp-flies, 371
Kempynus, 320; *citrinus*, 320; *incisus*, 320
Kennedya, 69, 70, 73, 476; *mirabilis*, 68; venation, F3
Kershawia, 200; *ruficeps*, 200; pl.16, f.9
Killing-bottles, 487, ZB2
King Beetles, 230; Crickets, 97, 89
Kirkaldy, G. W., 142
Kirkaldyella, 152
Kite Papilios, 450
Kiwi, parasites of, 134; relationships of, 134
Kootchar, 303
Koroana, 166; *helena*, Q29
Kurrajong tree, see *Brachychiton*, galls of, 277

Labdia, 426; *deliciosella*, 426
Labella, 335
Labelling, 495
Labidura, 111; *pluvialis*, 111; *riparia* 111; *truncata*, 111
Labiduridae, 111
Labiduroidea, 111
Labiduromma, 109
Labiidae, 112
Labium, 12, 16, A6, B1,D, F2,C, D
Labrum, 15, 12
Labrum-epipharynx, 234, 380
Labyrinthodont, 477
Lac, 174
Lac-insects, 174
Laccopterum, 191
Laccotrephes, 157; *tristis*, 157; pl.12, f.17
Lacebark, insects on, 423
Lace Bugs, 151
Lacewings, 308, 313. Brown, 317; Green, 318; Moth, 314, 230; Silky, 315
Lacinia, 15
Laron, 220
Lactura, 422; *caminaea*, 422; pl.27,f.7; *erythractis*, 422; pl.27,f.8; *suffusa*, 422
Lady-birds, 204
Laemosaccinae, 245
Laemosaccus, 245
Lagria, 223; *formicicola*, 223; *grandis*, 223; pl.18,f.15
Lagriidae, 223
Lagriaida brouni, 223
Laius, 213
Lambertia, insects on 173
Lambula, 444
Lameere, A., 24, 59, 67, 68, 142, 199
Lamellate antenna, 15, A4,G
Lammellicornia, 226
Lamiinae, 234
Lamp collecting, 489
Lamprina, 227; *latreilli*, 227; pl.15,f.18; *micardi*, 227; *splendens*, 227
Lamprogaster, 371; *flavipennis*, 371; *lacta*, 371; pl.20,f.27
Lamprotatus, 277
Lampyridae, 212
Lampyrinae, 213
Lampyroidea, 211
Lantana, insects at, 448
Laphria, 363; *clavata*, 363; pl.25,f.17; *rufifemorata*, antenna, W1,E
Laphriinae, 363
Laportea gigas, insects on, 236
Larentia, 452; *chlamydota*, 452; pl.38, f.23; *chlorias*, 452 *clarata*, pl.31, f.28; *epicrossa*, 452; pl 39,f.20; *oraria*, 452; *pseudostenaria*, 452; pl 33,f.27
Larentiidae, 452
Large Skipper, 457
Larra, 299; *melanocnemis*, 299
Larridae, 299
Larva, 41
Larvae, preparations of, 497
Lasiellidea, 153
Lasiocampidae, 437
Lasiocampoidea, 436
Lasioderma serricorne, 215
Lasiopsocus, 130
Lasiorrhynchus barbicornis, 240; pl.19, f.14
Laspeyresia, 427; *anoantica*, 427; *exemplaris*, 427; *hemicosma*, 427; *martia*, 427; *pomonella*, 427; *zapyrana*, 427
Lateral margin (elytron), 179
Lathrecista, 86; *asiatica festa*, 86; pl. 5,f.9
Lathridiidae, 204
Lathridius, 204; *costulatus*, 204, R32
Lathropus, 199
Laticephalum, 134
Latometus pilipes, 425
Latumcephalum, 134n
Laughing Jackass, parasite of, 377
Lauraceae, insects on, 450
Lauxania, 371
Lauxaniinae, 371
Lea, A. M., 185, 188 219, 222, 234n
Leaf Beetles, 234; Butterfly, Queensland, 463; Bugs, 152
Leaf-cutter Bees, 304
Leaf-hoppers, 163
Leaf Insects, 93
Leaf-miners, 372, 421, 426
Leaf-rollers, 427; parasite of, 285
Leaia mitchelli, 470
Leaiopria, 282
Leanymus mirus, 210; pl.16,f.4
Leasia, 235
Lebiinae, 192
Lecanium, 174; *oleae*, 174; parasite of, 276, 277
Lecaniinae, 174
Ledra, 165
Ledrinae, 165
Ledropsis, 165

Legs, 19, T7
Leistarches, 151
Lemidia, 213; *hilaris*, 213; *mastersi*, 213
Lemodes, 223; *coccinea*, 223; pl.18,f.17
Leperina, 201; *decorata*, 201; *nigrosparsa*, 201; pl.18 f.2
Lepidiota, 229, 230
Lepidocyrtoides, 56
Lepidocyrtus, 56
Lepidoderma albohirtum, 230
Lepidophorella, 56; *brachycephala*, 56
Lepidophthirus macrorhini, 134
Lepidopsocidae, 129
Lepidoptera, 7, 396; genitalia, Z7, Z8
Lepidosaphes, 174; *ulmi*, 174
Lepidoscia, 421; *palleuca*, pl.33,f.1
Lepidotarsa, 425; *chryserythra*, 425; pl.28,f.31
Lepinotus inquilinus, 129, 496
Lepisma saccharina, 49
Lepismatidae, 49
Lepismatinae, 49
Leptachrous strigipennis, 233
Leptidae, 358
Leptocarpus, insects on, 163
Leptoceridae, 392
Leptochirinae, 210
Leptochirus samoensis 210
Leptoconops, 352; *stygia*, 352
Leptocorisa, 148; mimic of, 234; *acuta*, 148; pl 12,f.6
Leptocorisinae, 148
Leptogaster, 363, 364; *antipodum*, 363, W51; *fumipennis*, 363; *geniculata*, 363
Leptogasterinae, 363
Leptogenys, 288
Leptoglossus, 147; *membranaceus*, 147
Leptomeris rubraria 451; pl.39,f.14
Leptomyrmex, 289; *erythrocephalus*, 289; pl.21,f.21; *varians*, 289
Leptoperla beroë, 119
Leptoperlidae, 119
Leptoperloidea, 118
Leptophlebiidae, 63
Leptopinae, 242
Leptops, 242; parasites of, 270; *areolatus*, 242; pl.19,f.17; *gladiator*, 242; *hopei*, 242; *rhizophagus*, 242; *robustus*, 242; *squalidus*, 242; *tribulus*, 242
Leptospathius, 269
Leptospermum, insects on, 217, 234, 329, 332, 359; collecting at, 488; galls on, 285; *scoparium*, insects on, 229
Leptospira icteroides, 351
Leptotarsus, 348
Leria, 371
Lerp-insects, 170
Lesser House-fly, 374
Lestidae, 78
Lestis, 304; *aerata*, 304; pl.21,f.32; *bombylans*, 304
Lestoidea, 78
Lestoideinae, 78
Lestophonus, see *Cryptochaetum*, 373
Lestremyia, 357
Lestricothynnus, 294
Lethocerus indicus, 157; pl.12,f.16
Leto, 413, 414; *stacyi*, 413, 408; pl. 29; larva, Z10; pupa, Z14
Leucania, 442; *purdiei*, 442; *sulcana*, 442; pl.31,f.20
Leucaspis, 174; *stricta* 174
Leucocytes, 33
Leucophenga, 373, 374n
Leucoptera, 421, 419
Leucorrhiniinae, 86
Leucospidinae, 273
Lexis, 444; *alterna*, 444; pl 32,f.20
Lias, English, 469
Libellaginidae, 80
Libellulidae, 85
Libellulinae, 86
Libelluloidea, 84
Libytheinae, 461
Lice, 131; Bird, 133; Biting, 133; Sucking, 134
Lichenaula melanoleuca, 426; pl.28,f.38
Licyllus splendidus, 236
Life History, 39, A20, A21
Ligula, 17
Liliaceae, insects on, 441
Lillipilli, see *Eugenia* 413
Limacodidae, 436
Limnephilidae, 393
Limnia, 371; *obscura*, 371; pl.2,f.28; *tranquilla*, wing, W65
Limnobia, 348
Limnobiinae, 348
Limnoecia, 426
Limnophila, 348
Limnophilinae, 348
Limnophora, 374
Limosina, 373
Limulodes, 211
Linognathus, 135; *ovillus*, 135; *pedalis*, 135, O3; *piliferus*, 135; *vituli*, 135
Liochora, 206
Liothrips, 139
Liparetrus, 229; *discipennis*, 229
Liparidae, 440
Liparis, 440n
Liparomyia, 365
Lipeurus, 134
Liphyra brassolis, 454
Liphyrinae, 464
Lispa, 374
Lissapterus, 227
Lissomus vicinus, 219
Lissonota, 269
Lissopimpla semipunctata, 269; pl.21, f.5
Lissotes, 227; *acmenus*, 227; pl.18,f.28; *obtusatus*, 227; *punctulatus*, 227
Lissotrachelus, 97; *maoricus*, 97
Lita solanella, 426
Lithosiinae, 444

Lithurgus, 304
Litochrus maculatus, 203, R30
Lobogethes interrupta, 445; pl.28,f.60, 61
Locust, Crested, 98; Long-nosed, 98; Plague, 98; Red-legged, 98; Ridge-backed, 98; Rose-winged, 98; Spotted, 98
Locusta, 98, 95n; *australis*, 98; *danica*, 98; *migratoroides*, 98
Locustidae, 95n
Locustivora pachytyli, 376
Locusts, Cave, 95; Long-horned, 95; Pigmy, 99; Short horned, 97
Loew's Notation (Diptera), 338
Lollius, 169
Lomaptera, 231; *duboulayi*, 231; *yorkiana*, 231; pl.15.f.2;
Lomatiinae, 364
Lomemus, 220
Lonchaea aurea, 371, *splendida*, 371
Lonchaeinae, 371
Long bridge, 70
Long-horned Caddis-flies, 392
Long-legged Fly, 376
Long-tailed Wasps, 267
Longicorns, 231
Longurio dux, 348; pl.25,f.2
Loopers, 405
Lophioneura ustulata, 472, ZA2
Lophopepla, 425
Lophopidae, 169
Lophops, 169; *saccharacida*, 169, 233
Lopus, 153
Loranthus, insects on, 463, 465
Louse-flies, 377
Lower Permian, 469
Loxocera, 372
Loxopleurus, 235
Lubra regalis, 165, Q28
Lucanidae, 227
Lucia lucana, 466; pl.40.f.7
Lucilia caesar, 375; *sericata*, 375
Luciola, 213
Luperus, 236
Lycaena phoebe, 466
Lycaenidae, 464
Lycaeninae, 465
Lycaon novus, 219, R50
Lychnographa, 451
Lycinae, 212
Lycopsylla, 384
Lyctidae, 203
Lyctocoris campestris, 153, Q12
Lyctus, 203; *brunneus*, 203
Lygaeidae, 146
Lygaeinae, 146
Lygaeus, 146, 147; *singularis*, 147; pl. 12.f.1; hemielytron, Q2
Lygesis, 234
Lygocerus niger, 283
Lymantria reducta, 439, 441; pl.30.f. 22
Lymantriidae, 440
Lymexylidae, 213
Lymexylon, 213
Lyonetia, 421
Lyonetiinae, 421
Lyperobius hudsoni, 242; pl.2,f.18
Lyperosia exigua, 375
Lysiphragma, 426

Macalla, 432
Maceration, 498
MacGillivray, A. D., 255
Machaerotinae, 163
Machilidae, 49
Machimia, 424; *pudica*, 424; pl.30,f.1
Machomyrma, 289
Macquartia, 375
Macramycterus, 242; *schoenherri*, 242, R75
Macratria, 224
Macrobathra, 425; *argonota*, 425; pl. 28,f.35
Macrocalymma, 296
Macrocera, 353; *decorosa*, 353; pl.20, f.19
Macrocerinae, 353
Macrochaeta, 374
Macrodontomerus, 275
Macroglossum, 448; *hirundo errans*, 448; pl.36,f.4; *micacea*, 448; *nox*, 448; *tenebrosum*, 448
Macrogyrus, 194; *latior*, 194; pl.17, f.16; *striolatus*, 194, R20; larva, R8
Macrohelodes, 214
Macromalocera, 270
Macromastix, 348, 349; *albistigma*, 348; *costalis*, 348; *dichroithorax*, wing, W24; *ferruginosa*, 348; pl.2. f.24; *zeylandiae*, 349
Macromerus, 293
Macromia, 84
Macromiinae, 84
Macronema, 392; *pulchripenne*, 392
Macronematinae, 392
Macropanesthia rhinoceros, 92; G2, A; egg-capsule G2,B
Macropiper excelsum, insects on, 443
Macropocopris symbioticus, 228, R59
Macroporus howitti, 193
Macropsylla hercules, 384
Macropus, parasites of, 228
Macrorhinus, 135
Macroura concolor, 202
Macrosiphum granarium, 172; *rosae*, 172; *solanifolii*, 172
Macroteleia, 283
Macrotrichia, 21, 399
Macrotristria, 162; *angularis*, 162
Maechidius, 229; *tibialis*, 229
Magdalinae, 244
Magdalis, 244
Maggot, 342
Magnesia, powdered, use of, 497
Mahoe, insects on, 442
Malachiidae, 213
Malachiinae, 213
Malacodermata, 211
Malacodermidae, 212
Malaria, carriers of, 351
Male genitalia, A11

Maleuterpes phytolymus, 241
Mallodeta, 453
Mallophaga, 133, 5
Malpighian tubules, 31, 32
Malvina punctata, 282
Mandalotus, 242
Mandevillea, insects on, 461
Mandible, 15; B1,B, F2,A
Manica, 403
Mantidae, 92; parasites of, 274
Mantispa, 319; *australasiae*, 319, pl.22, f.16; *strigipes*, 319; *vittata*, 319; larva, U13.
Mantispidae, 318.
Mantoidea, 92.
Manubrium (Collembola), 54, (Dermaptera), 109
Manuka, see *Leptospermum scoparium*
Manuka Beetle, 229
Many-plumed Moths, 429
Marava, 112; *grandis*, 112
March-flies, 358
Margareta dominica, 147
Margaris, 210
Margarodinae, 173
Margaronia, 432; *atletalis*, 432; *canthalis*, 432; pl.27,f.20; *excelsalis*, 432; pl.30,f.5; *floridalis*, 432; *glauculalis*, 432; *suralis*, 432; pl.27, f.19
Marginal cell, 271
Maria, 363
Marine Caddis-fly, 394, Y13, larva Y8, case Y9.
Marmasoma, 364
Maroga, 425; *setiotricha*, 425; *unipunctata*, 426
Marsupials, parasites of, 377, 383, 384
Maruca testulalis, 432.
Masaridae, 296
Mask, labial, 72, F5
Mason Bees, 297n
Mason jars, 498
Mason Wasps, 295, 297; New Zealand, pl.21,f.27
Mastachilus, 226
Mastotermes, 102, 104; *darwiniensis*, 105, pl.6,f.7, venation, H3
Mastotermitidae, 105
Matinus, 156
Maxilla, 15, A5, B1,C, B2,A,B, F2,8, Z2
May-flies, 57; male genitalia, A11
Mazon Creek, fossils, 468.
Meal Moth, 433; Indian, 434
Mealworm, dark, 223; yellow, 223
Mealy-bugs, 172, 173, 174
Mecodema o'connori, 191; pl.17,f.3
Mecoptera, 326, 6; Permian, 472; Triassic, 475
Mecopteroid Orders, 23, 326n, 472
Mecopus, 245
Mecyna, 431; *maorialis*, 431; pl.31, f.6; *ornithopteralis*, 431
Mecynodera coxalgica, 235
Mecynotarsus albellus, 223, R55
Media, 22
Median cell, 337; lobe, 182; segment, 253, 259
Mediterranean Flour Moth, 434; Fruit-fly, 372
Megacephala, 192; *australis*, 192; pl 15,f.1; *crucigera*, 192
Megachile, 304; *apicata*, 304; *cetera*, 304; *chrysopyga*, 304; *macularis*, 304; *mystacea*, 304; *quinquelineata* 304, T51
Megachilidae, 304
Megachilinae, 304
Megalecchthrus tryoni, 251
Megaleptoperla, 119; *grandis*, 119; larva, K3
Megalestes, 78
Megalomus, 318
Megalopaussus amplipennis, 194
Megaloptera, 313, 6
Megalothynnus, 294
Megalotrox dohrni, 228; pl.18,f.29
Megalyra, 267; *fasciipennis*, 268; pl. 20,f.2; wings, T16
Megalyridae, 267
Megamerus kingi, 235; pl.19,f.1
Megapodagriidae, 78
Megapsychops illidgei, 315, 312, 476; pl.22,f.2
Megarhyssa fractinervis, 269, pl.2,f. 19
Megasecoptera, 481
Megaspilus, 283
Megastigminae, 275
Megastigmus, 275
Megophthalminae, 163
Megophthalmus, 163
Megymenum insulare, 148
Meinertellinae, 49
Melaleuca, insects on, 174
Melampsalta, 161; *abdominalis*, 161; *cincta*, 161; *cingulata*, pl.2,f.9, head, Q1; larva, Q21; *cruentata*, 161; *muta*, 161; *torrida*, 161.
Melanchra, 442; *coeleno*, 442; *maya*, 442; pl.38,f.10; *meyricki*, 442; pl.38, f.9, *mutans*, 442; pl.31,f.18; wings, Z41; *paracausta*, 442; pl.31,f.17; *rubescens*, 442; pl.31,f.16
Melanchrinae, 442
Melandryidae, 223
Melanitis, 462; *leda bankia*, 462
Melectidae, 303
Melia Azedrach, insects on, 441
Melicytus ramiflorus, insects on, 442
Meliphora grisella, 434
Meliponinae 305
Melittia, 424; *amboinensis*, 424
Melittobia, 278
Melitulias discophora, 452; pl.39,f.23
Mellitidia, 303
Melobasis, 218; *cuprifera*, 218; *gratiosissima*, 218; pl 15,f.10; *metallifera*, 218; pl.15,f.11; *nervosa*, 218; *nobilitata*, 218; *purpurascens*, 218; *superba*, 218
Melolonthinae, 229

Melolonthoid larvae, 42, 183
Melon Aphis, 172
Melophagus ovinus, 378
Melophorus, 290; *advenus*, 290; *bagoti*, 290; *cowleyi*, 290
Melyridae, 213
Melyrinae, 213
Membracidae, 165
Membrane, 141, 144
Membranule, 80
Mendelian characters, in *Tisiphone*, 462
Menelaïdes, 458, 459
Menemachinae, 245
Mengeidae, 251
Mengenilla, 251
Mengenillidae, 251
Mengeoidea, 251
Menimus, 222
Menopon, 134; *gallinae*, 134; *pallidum*, 134
Menopidae, 134
Mentum, 17
Meranoplus, 28?
Merimna, 218; *atrata*, 218, R49
Meriphrus, 243
Merizodinae, 101
Meroglossa, 303
Merope, 329
Meropidae, 329, 330
Meryx, 200
Mesetia amoena, 240
Mesochoristidae, 329
Mesocolon, 208
Mesogereon superbum, ZA8
Mesogereonidae, 143, 475
Mesoleptus, 269
Mesolita myrmecophila, 234
Mesomantidion, 476
Mesopleuron (Diptera), 336
Mesoponera constanea, 288
Mesopsocidae, 130
Mesorthopteron, 476; *locustoides*, 476
Mesostenus albopictus, 269
Mesothorax, 18
Mesotitan, 474n
Mesotrichia, see *Xylocopa*, 304
Mestressa, 324
Mesynognathus dameli, 191; pl.18, f.8
Metablax acutipennis, 220; pl.18.f.22
Metaclisis olcariae 284
Metacrias, 444; *erichrysa*, 444; pl.38, f.13
Metagea rufiventris, 275, T24
Metalaphria, 363
Metallarcha, 431, 432
Metamorphosis, 44, 42
Metanotum (Diptera), 336n
Metaparagia, 296; *maculata*, 296
Metapleuron (Diptera), 336
Metapone, 289
Metaprotus, 431
Metapygidium, 109
Metasia, 431
Metastathius apterus, 269
Metatarsus, 19
Metathorax, 18
Metazymorpha, 217, 218; *gloriosa*, 218; *grayi*, 218
Meteorus, 269
Methana, 91; *marginalis*, 91; pl.7.f.2
Metopius unifenestratus, 269; pl.20, f.3; wings, T18
Metoponia rubriceps, 360
Metriorrhynchus, 212, 213, 217, 225, 226; mimics of, 243, 423; larva, R10; pupa, R15; venation, R5; *batesi*, 212; *rhipidius*, 212; pl.18.f.6; *rufipennis*, 212
Metura, see *Oeceticus*, 435
Miastor, 357
Micrarchus, 94
Microctyche, 222
Microbracon, 269
Microdes, 445, 415n, 452
Microdon, 368; *variegatum*, 368, W63; larva and puparium, W64
Micromasoria caelata, 166, Q30
Micromus, 318; *tasmaniae*, 328; wings, U10
Microrecta, 158
Micronia, 445
Micropardalis doroxena, 412; pl.28, f.4
Micropterygidae, 412
Micropterygoidea, 410
Micropyle, 39
Microsania stigmaticalis, 366
Microscope, 498
Microscopic preparations, 498
Microtragus, 234; *luctuosus*, 234
Microtrichia, 21, 399
Micro-trichoptera, 393
Microtropesa sinuata, 376
Microvalgus, 231
Microvelia, 153; *australica*, 153; *macgregori*, 153; sp. indet. Q14
Mictinae, 147
Mictis, 147; *profana*, 147; pl.12.f.5
Midges, 352, 357
Midgut, 31
Milesia bilineata, 368; pl.25.f.24
Miletus, 466; *hecalius*, 466; pl.40.f.6; *ignitus*, 466
Miltinus, 363; *viduatus*, 363; pl.25, f.20; wing, W54
Mimarchus, 94
Mimelogonalos bouvieri, 291
Mirambiyaspis, 284
Miridae, 153
Miris, 152
Mirobacoides, 283
Mirobacus, 283
Miroidea, 152
Miroteleonomus, 283
Mirror, 160
Miscogaster, 277
Miscogasterinae, 277
Misophrice, 243
Mitchell, J., 470
Mitophyllus, 227; *parryanus*, 227
Mnesarchaea, 414; *hamadelpha*, 412; pl.28,f.5; scale, Z4,B; *loxoscia*, 412; *paracosma*, 412

Mnesarchaeidae, 412
Mnesictena, 429n
Mochlonyx, 352
Moerarchis, 421; *australasiella*, 421; pl.27,f.4; *dictyotis*, 421
Molannidae, 390
Mole Crickets, 97
Molophilus, 348; *pulcherrimus*, larva, W14; pupa, W18
Molytinae, 242
Monerebia, see *Abispa*, 295
Moniliform antenna, 14; A4,C
Monistria, 98; *conspersa*, 98, G11
Monochirus multispinosus, 237, R67
Monochrysis, 286
Monocrepidius, 220
Monocteniidae, 449
Monohammus, 234
Monolepta divisa, 236; *rosea*, 236
Monomma, 225
Monommatidae, 224
Monomorium, 288; *antarcticum*, 288; *nitidum*, 288; *pharaonis*, 289, *rubriceps*, 289
Mononyx, 156; *annulipes*, 156
Monophlebinae, 173
Monophlebus, 173; *crawfordi*, 173
Monopis, 421; *ethelella*, maxilla, Z4, B
Monopola miltogramma, 436
Montezumia, 296
Mordella, 225; *dumbrelli*, 225; *leucosticta*, 225; pl.18.f.19; *tairuensis*, 225
Mordellidae, 225
Mordellistena, 225
Mormoniella brevicornis, 375, 277
Moreton Bay Fig, insects on, 276
Morgan, Anna, 59
Morova subfasciata, 431; pl.31,f.5
Morphology, external, A1; internal, A12
Mosaic Vision, theory of, 35
Mosquitoes, 350; mouth-parts, W5
Mossega indecisa, 323; pl.24.f.5
Motasingha, 457
Moth-lacewings, 314, 230
Moth-midges, 350
Moths, 396
Mottled Brown Cicada, 162
Mould, 496
Mound Ant, 289
Mount Elliott mine, fossils in, 479
Mounting, 494
Mounting medium, formula, 494
Mouse Flea, 382, 384
Mouth, 31
Mouth-parts, 15, A2, A3
Mucidus alternans, 351, W32
Mucro, 54
Mud-daubers, 295, 301
Muehlenbeckia, insects on, 431, 466
Muir, F., 152, 153, 165n
Mulga, insects on, 135
Müller, J., 35
Munichryia, 439, 438
Musca, 375; *domestica*, 375, 343; *pumila*, 375; *vetustissima*, 375
Muscidae, 375
Muscina, 374; *stabulans*, 375
Muscinae, 375
Muscles, 30; alary, 33
Muscoidea, 368
Museum Beetles, 206
Mussel Scale, 174
Mutillidae, 295
Mycetophagidae, 202
Mycetophila, 354; *robusta*, wing, W35
Mycetophilidae, 352
Mycetophilinae, 353
Mycetophiloidea, 352
Mychestes, 222
Mycopsylla, 171
Myctides barbatus, 245
Mydaidae, 363
Myers, J. G., 150, 154
Myiodactylus, 322
Myiodactylidae, 322
Myiodaria, 368, 365
Myllocerus, 242; *abundans*, 242, R74
Mymaciellus, 244
Mymaridae, 279
Myodochidae, 146
Myolius chalcopterus, 209
Myopsocidae, 130
Myopsocus, 130; *australis*, 130; *griseipennis*, 130; *novae-zelandiae*, 130; pl.2,f.6, tarsus, M1, D.
Myrmecia, 287, 286, parasites of, 275, *auriventris*, 287; *forficata*, 287; *gulosa*, 287; pl.21,f.17-19; wings, T40; *nigrocincta*, 287; pl.21,f.20; *pyriformis*, 287; *tarsata*, 287
Myrmecinae, 288
Myrmecomantis, 93
Myrmecoridea, 153
Myrmeleon, 4, 324, 323; *aculus*, 324; pl.24.f.7, *croceicollis*, 324; *pictifrons*, 324; *uniseriatus*, 324; wings, U15
Myrmeleontidae, 323
Myrmeleontinae, 323, 324
Myrmeleontoidea, 321
Myrmicholeva, 208
Mystes planatus, 223
Mytilaspis, 174; *pomorum*, 174
Myzus cerasi, 172; *persicae*, 172

Nabidae, 150
Nabis, 150; *capsiformis*, 150, Q7; *geniculatus*, 150; *maoricus*, 150
Nacaduba, 466; *biocellata*, 466
Naiad, 42, 72
Nannochorista, 331; *dipteroides*, V7; head, V2
Nannochoristidae, 331
Nannophlebia, 86; *risi*, 86; pl.5,f.7
Nannophya, 86; *dalei*; pl.5.f.10
Naphthalene, use of, 496
Narellan Fossil Beds, 477; pl.33,f.1
Narycia, 421; *palleuca*, 421; *saxosa*, 421; *trifasciana*, 421; pl.28,f.6
Nascio, 218; *vetusta*, 218

Nascioides enysi, 216
Nasonia, see *Mormoniella*
Nasute soldier, 103
Natalis titana, 213
Nataxa flavescens, 439; pl.27.f.25
Native Cats, parasite of, 384
Native Cherry, see *Exocarpus*, 425
Native Flax, New Zealand, see *Phormium tenax*
Native Flax Moth, 452
Native Mistletoe, see *Loranthus*, 463
Naucoridae, 157
Naucoris, 157; *australicus*, 157
Nausinoë pueritia, 434; pl.30,f.6
Navas, L., 324
Navomorpha lineata, 233; pl.2.f.15
Neanurinae, 55
Nearcha, 449; *curtaria*, 449; pl 39.f.4
Neargyria, 433; *argyraspis*, 433; pl.33, f.12
Neck, 12, 18
Necrobia ruficeps, 213; *ruficollis*, 213
Necrodes osculans, 208
Necrophilus prolongatus, 208
Necrophorus, 208
Neda princeps, 205
Needham, J. G., 67, 68; and Morgan, Anna, 25
Needle-bugs, 157
Neides wakefieldi, 148, Q5
Neididae, 148
Nematocera, 346
Nemeobiinae, 461
Nemestrinidae, 360
Nemobius, 97
Nemopalpus, 350, 346; *zelandiae*, 350, W31; wing, W30
Nemopteridae, 321
Nemopterinae, 321
Nemopteroidea, 320
Nemoraea, 376
Nemotois, 420; *sparsella*, 420; pl 27, f.3
Nemouridae, 119
Nemouroidea, 119
Neoaratus, 363; *hercules*, 363; wing, W52
Neobelyla aurea, 282, T31
Neoceratina, 305
Neocharis, 219
Neocuris, 218; *eremita*, 216
Neocurupira, 355; *hudsoni*, 355, W37; *nicholsoni*, 355
Neodixa, 352; *minuta*, 352
Neodrepta luteactella, 426; pl.33.f.6
Neodryinus, 285; *raptor*, 285, T37
Neoexaireta apicalis, 360; pl.2.f.25; *spinigera*, 359; pl.25.f.9; wing, W46
Neohesperilla, 457
Neoitamus, 363; *vulgatus*, tarsus, W7.
Neola semiaurata, 446
Neolucia, 466; *agricola*, 466; *hobartensis*, 466
Neomegastigmus, 275
Neoneurys, 265
Neopollenia, see *Anastellorhina*, 375
Neoreta erminea, 439; pl.30,f.20
Neorupilia, 236
Neosarapogon, 362; *princeps*, 362
Neoscelio, 283
Neospades, 216
Neossiosynoeca scatophaga, 425
Neosticta canescens, 76; venation, F6
Neosyagrius, 242
Neoteinic Royalties, 103
Neozeleboria, 294
Nepharina, 199
Nepharis, 199; *alata*, 199; pl 16.f.3.
Nephele subvaria, 448
Nephopteryx, 434
Nephotettix, 163
Nepidae, 157
Nepticula, 421
Nepticulinae, 421
Nerius, 371; *inermis*, 371, *lineolatus*, 371
Nervijuncta, 354; *hudsoni*, 354; pl.25, f.4; *wakefieldi*; wing, W36
Nervous System, 34
Nervures, see Wing-veins
Nesocyphon, 214
Nesogaster ruficeps, 112
Nesomachilis maoricus, 49, B1; hypopharynx, A7,A
Nesoperla, 119
Nesoxenica, 462; *leprea*, 462; pl.43.f.8
Netrocoryne repanda, 456; pl.44.f.1
Nets, insect, 485
Nettles, see *Urtica*
Net-veined Midges, 355
Neurobasis chinensis australis, 80; venation, f.14
Neurochorema, 391
Neuroctenus, 150
Neurogalesus, 282
Neuroptera, 6, 308; egg, A18,C; Permian, 472; Triassic, 476.
Neurothemis, 85
New Zealand Army Worm, 442; Copper, 466; Elephant Beetle, 245; Giraffe Beetle, see *Lasiorrhynchus barbicornis*, 240; Insect Fauna, 480; Red Admiral, 463
Newcastle Fossil Beds, 469
Nezara viridula, 149; life history, A20
Nickerlea, 192
Nicoletiinae, 49
Night collecting, 489
Niguza, 443; *eucesta*, 443
Niphonympha, 421
Nitela, 299
Nitelidae, 299
Nitella, insects on, 393
Nitidulidae, 202
Noctuidae, 441
Noctuinae, 443
Noctuites, 437, 438
Noctuoidea, 437
Nodus, 68
Nola, 444
Nolidae, 443
Nomada australensis, 303
Nomadidae, 303
Nomia, 303

Nominae, 303
Nomoides, 303
Nomophila noctuella, 432
Nosodendron, 206
Nososticta solida, 76.
Notal process, 21
Notanatolica, 392; *cognata*, 393; *magna*, 393, Y11
Nothiphila, 373
Nothochrysa, 318; *insignis*, 318; pl.22, f.14; wings, U11
Nothofagus, insects on, 49, 394, 479
Nothopanax, insects on, 451
Notiobiella, 318
Notiothauma, 329, 475
Notoblattites, 477
Notodontidae, 446
Notodontoidea, 445
Notogonidea, 290
Notolepisma zelandica, 49, B3
Notolestus sulcipennis, 191; pl.15,f.3.
Notoncus, 290
Notonecta, 157
Notonectidae, 157
Notonectoidea, 156
Notonemoura latipennis, 119
Notonomus, 191; *arthuri*, 191; pl 17, f.6
Notoreas, 452; *brephosata*, 452; pl.38, f.18; *niphocrena*, 452; pl.38,f.19; *synclinalis*, 452; pl.38,f.20.
Notoulus, 200
Notum, 18
Novapus, 230; *bifidus*, 231
Novius cardinalis, 173, 205
Nuclei of Semper, 35
Nusa, 363
Nyctalaemon patroclus, 445
Nyctemera, 440; *amica*, 440; mimic of, 439; *annulata*, 440; pl.31,f.15
Nycteribia, 378
Nycteribiidae, 378
Nycterimyia, 361
Nyctozoilinae, 222
Nyctozoilus, 222
Nymph, 42, 72
Nymphalidae, 461
Nymphalinae, 463
Nymphaloidea, 460
Nymphes myrmeleonides, 322; pl.24, f.3
Nymphidae, 322
Nymphidrion, 322
Nymphula, 432; *nitens*, 432
Nysius, 146; *clavicornis*, 147, Q3, *vinitor*, 147
Nysson, 299; *brisbanensis*, 299.
Nyssonidae, 299
Nyssoninae, 299
Nyxetes bidens, 245, R79

Oak Scale, 174; parasite of, 278
Oamaru Fossil Beds, 469
Oblique Vein, 24, 70, F8, F10, F16, U15
Oblongum, 180
Occiput, 12
Occisor, 376
Ocelli, 36, 13
Ochlerotatus, see *Aedes*, 351
Ochrocydus huttoni, 232
Ochrogaster, 447; *contraria*, 447
Ochteridae, 156
Ochteroidea, 156
Ochterus marginatus, 156
Ocypteropsis flavifrons, 376
Odonata, 65, 3; Permian, 468; Triassic, 476; external morphology, F1
Odontaulacus, 368; *albosignatus*, wings, T17
Odontoceridae, 390
Odontomachus, 288
Odontomyia, 360; *atrovirens*, 360; *decipiens*, 360; pl.25,f.8; larva, W16
Odontria, 229; *striata*, 229; *zelandica*, 229, R60
Odynerinae, 295
Odynerus, 295; mimics of, 368; *bicolor*, 295; *mirabilis*, 295; pl.21,f.12; *nigrocinctus*, 295
Oeceticus, 435; *elongatus*, 435; pl.32, f.2; *omnivorus*, 435
Oecetis, 392; *unicolor*, 392
Oechalia consocialis, 148
Oeconesus, 394; *maori*, 394; pl.26,f.12
Oecophoridae, 424
Oecophorinae, 425
Oecophylla virescens, 290; parasites of, 465
Oedaleus senegalensis, 98
Oedemeridae, 225
Oedipodinae, 98
Oedosmylus, 320
Oenochroma, 450; *vinaria*, 450; pl. 39,f.7
Oenochromatidae, 449
Oenocytes, 32
Oesophagus, 30
Oesophageal Valve, 31
Oestridae, 376
Oestrus ovis, 376
Ogmorhinus, 135
Ogyris, 465; *zosine*, 465
Oides, 236
Olbiogaster, 349
Olearia, galls on, 284
Oliarus, 166; *asaicus*, 166; *oppositus*, 166
Oligocene, New Zealand, 469
Oligochrysa, 318; *gracilis*, 318; wings, U12
Oligonephric Orders, 32
Oligoneura, 356
Oligosita, 279
Oligotoma, 122; *antiqua*, 122; *glauerti*, 123; male genitalia, L3; *gurneyi*, 123, L1, L2; *hardyi*, 123
Oligotomidae, 123
Olinga feredayi, 394; pl.2,f.22; pupa and case, Y7
Olive Scale, 174
Olliff, A. E., 470, 474
Omaliinae, 210

Omalium, 210
Omedes, 224; *fuscatus*, 223
Omma mastersi, 195; *stanleyi*, 194; pl.17,f.18; thorax, R22; venation, R4
Ommata, 13, D1,B
Ommatidium, 13, 406
Ommatius angustiventris, 363
Oncocephalus, 151; *confusus*, 151, Q8
Oncodes basalis, 360; *brunneus*, 360, W49; *nitens*, 360
Oncodocera, 364
Oncomeris flavicornis, 148; pl.12,f.9
Oncopeltus, 146, 147; *sordidus*, 147
Oncopera intricata, 413
Oncophysa vesiculata, 152, 210
Oniscigaster, 62; *distans*, 62; pl.10, f.2; larva, E2; *wakefieldi*, 62
Oniscosoma, 92; *granicollis*, 92; pl. 7,f.3,4
Onosandrus, 97
Onosterrhus, 222
Onthophagus, 228; *pentacanthus*, 228
Onychium, 214
Onychomyrmex, 288
Oopterus, 192
Ootetrastichus, 278; *beatus*, 278
Ootheca, 38, 89, G2,B, G5
Oothecaria, 90
Opatrinae, 222
Operculum, 160
Ophideres, 443; *fullonica*, 443; *materna*, 443; *salaminia*, 443; pl.35, f.4
Ophidius, 220; *histrio*, 220; pl.18,f.25
Ophiinae, 269
Ophion, 269
Ophrynopus, 265, *schauinslandi*, 265, T15; *sericatus*, 265
Ophryops dispar, 233; *setoceus*, 233
Ophthalmorychus 241
Ophyra, 374, 375; *chalcogaster*, 374, W70
Opifex fuscus, 351
Opisthomeres, 27, 109
Opisthopis, 390
Opisthoscelis, 173
Opistoplatys, 151; *australasiae*, 151; *fuscus*, 151
Opogona, 421; *comptella*, 421; pl.27, f.6
Opomyza, 372
Opomyzidae, 372
Opossums, parasites of, 384
Opostega, 421; *gephyraea*, 421
Oposteginae, 421
Opuntia, insects on, 174
Orange-suckers, 443
Orcus, 205; *chalybeus*, 205; pl.15,f.5
Orectognathus, 289
Oreixenica, 462, 455, 463; *correae*, 462; *kershawi*, 463; pl.40,f.9; *lathoniella*, 462; pl.43,f.7; *latialis*, 462; *orichora*, 462
Orgioneura, 269
Orgyia, 441; *anartoides*, 441; pl.30, f.24
Origin of the Australian and New Zealand Faunas, 468
Orimarga, 348
Oristicta, 76
Orneodes, 429; *phricodes*, 429; pl.28, f.52
Orneodidae, 429
Ornithoctona nigricans, 377
Ornithomyia, 377; *australasiae*, 377; W73; *perfusa*, 377; *stipituri*, 377
Ornithoptera, see *Troides*
Ornithorhynchus, parasites of, 384
Orocrambus, 433; *catacaustus*, 433; pl.31,f.14; *machaeristis*, 433; pl.31, f.13
Orophius, 202
Orophora unicolor, 435
Orphnephila, 352
Orphnephilidae, 352
Ortalidae, 371
Orthenches, 421; *glyptarcha*, 421; pl.28,f.11
Orthetrum, 86; *caledonicum*, 86; *sabina*, 86; *villosovittatum*, 86; pl.5, f.8; venation, F19
Orthocladius, 352
Orthocnemus, 151
Orthodera, 93; *ministralis*, 93; pl.6, f.2; egg-capsule, G5; morphology, A1
Ortholfersia macleayi, 377
Orthoprosope grisea, 368
Orthoptera, 4, 87
Orthorhinus, 243; *aethiops*, 243; *cylindrirostris*, 243; *klugi*, 243
Orthorrhapha, 357
Oryssidae, 265
Osca, 359; *auriflua*, 359; *bicolor*, 359; *concolor*, 359; *maculiventris*, 359; *subappendiculata*, 359; pl.25,f.6
Oscinella, 373
Oscinidae, 373
Oscinis, 373
Osidryas, 424
Osmeterium, 458
Osmylidae, 319
Osmylops, 322; *pallidus*, larva, U17; wings, U16
Ossa formosa, 166; *venusta*, 166
Ostenia, 365
Ostia, 33
Othius, 209
Otiorrhynchinae, 241
Otiorrhynchus, 242; *cribricollis*, 242; *scabrosus*, 242; *sulcatus*, 242
Ovarian tubules, 38
Ovary, 37, 38
Oviduct, 37
Ovipositor, 26, A10
Ovum, 37, 39, 40
Oxacis, 225
Oxybiella, 318
Oxycareninae, 147
Oxycarenus luctuosus, 147
Oxychirota, 415n; *paradoxa*, 430; pl.28,f.54
Oxychirotidae, 430

Oxycophina theorina, 430
Oxyethira, 393; *albiceps*, 393
Oxyhaloinae, 92
Oxyops, 242
Oxypsocus hamiltoni, 129; wings, N2
Oxythecta, 424
Oyster-shell Scale, 174

Pachycotes, 239, *ventralis*, 239, R70
Pachygastrinae, 360
Pachymorpha, 94; *hystriculea*, 94
Pachyprosopis, 302
Pachyrhamma acanthocera, 96; *fascifer*, 96, G8; hypopharynx, A7,B; labium, A6; maxilla, A5
Pachytomoides, 274
Pachytricha, 220
Pachyura, 243; *stictica*, 243
Packard, A., 2
Padraona, 456; *flavovittata*, 457; pl. 44,f.3; *lascivia*, 457
Paederinae, 209
Paederus, 209; *cruenticollis*, 210; *sparsus*, 209; pl.17,f.26
Paedogenesis, 44
Painted Lady, 463
Palaeodictyoptera, 58, 67, 468, 481
Palaeontinidae, 408n
Palaeorrhiza, 303; *reginarum*, 303
Palaeoses scholastica, 414; venation, Z21
Palaeosetidae, 414
Palaestra, 226; *rubripennis*, 226; pl. 18,f.20; claws, R57
Palimborus, 210
Palimmecomyia, 359
Palloptera, 371
Palpi, labial, 17; maxillary, 15
Palpicornia, 197
Palpifer, 15
Palpiger, 17
Palms, insects on, 456
Palophus titan, 94
Palorus, 222; *eutermiphilus*, 222; pl. 16,f.17
Pamborus, 191; *alternans*, 191; *opacus*, 191; pl.17,f.2
Panacela lewinae, 453; pl.30,f.25
Panacra splendens, 449
Panchlorinae, 92
Panesthia, 92
Panesthiinae, 92
Pangoniinae, 358
Paniscus, 269; *productus*, 269; pl.21, f.7; leg, T7,A; mouth-parts, T3,A-C; *testaceus*, 269
Panoïstic ovary, 38
Panops baudini, 360; pl.25,f.12
Panorpidae, 330, 326
Panorpoid Complex, 472, 326n
Pantala flavescens, 86
Pantotelinae, 245
Pantydia sparsa, 443; pl.32,f.19
Paper triangles, 486, ZB1
Papilio, 458; *aegeus*, 459; pl.41,f.1; pupa, Z63; *agamemnon ligatus*, 460; pl.40,f.3; *anactus*, 459; pl.44,f.6; *aristeus parmatus*, 459, 460; pl.44, f.7; *demoleus sthenelus*, 459; *eurypylus lycaon*, 460; pl.44,f.8; *leosthenes*, 459; *macleayanus*, 460; pl. 40,f.2; *priamus euphorion*, 459; pl. 40,f.4; *sarpedon choredon*, 459; larva, Z60; pupa, Z61; venation, Z59; *ulysses joesa*, 459; pl.41,f.2
Papilionidae, 458
Papilionoidea, 457
Paprides, 98; *nitidus*, 99; pl.7,f.15
Parabelmontia, 344; *permiana*, 471
Parabetyla spinosa, 282
Paracanthocera, 359
Paracladura, 348
Paracolletes, 302; *obscurus*, 302
Paracupta albivittis, 219
Paracurupira, 355
Paradermaptera, 111, 111n
Paradorydium, 163
Paradryinus, 285
Paraffin-wax, use of, 497, 500
Paraglossa, 17
Paragnath, 17, 53, A7
Paragonotopus, 285
Paragryllacris, 95; *combusta*, 96, G7
Paragryon castaneus, 283
Parahelcon, 269
Paraheterodoxus, 134
Parahippelates, 373
Parahyadina, 373
Paralastor, 295; *eriurgus*, 295
Parallelia propyrrha, 443
Paralucia aurifera, 465; pl.40,f.8
Paramecoptera, 330, 344, 389, 472, 475, 481
Parameres, 27
Paranagrus, 280; *optabilis*, 280
Parandra, 198 199, 231; *frenchi*, 199; pl.17,f.21
Parandrinae, 199
Paraneuroptera, see Odonata
Paranomina, 271
Paranotal expansion, 20
Paranotoperla, 119
Paranyssoninae, 299
Paranthrene oberthuri, 424
Paraphyllis, 421
Parapleura, 178n
Paraprocts, 27
Parapsidal furrows, 18
Parapsides, 18, 253
Parapsocida, 129
Parapsyllus australiacus, 384
Parapteron, 21, 398
Pararatus, 363
Pararhopaea, 229, *gigas*, 229
Parasemidalis, 320; *farinosa*, 320
Parasemus victoriensis, 203
Parasilvius, 359
Paraspheeodes, 303
Paraspinophora, 366
Parastephanellus, 268
Paratettix, 99; sp. indet., G12
Paratrichoptera, 330, 344, 476, 481

Parectopa, 421; *citharoda*, 422; *ida*, 421; pl.28,f.12; *zorionella*, 422; pl. 28,f.13
Parlatoria, 174
Parnidae, 216
Paronella, 56
Paropiinae, 163
Paropsis, 236; larva, R12; *gibbosa*, 236, R65; *immaculata*, 236; *orphana*, 236; *sexpustulata*, 236; *vittipennis*, 236
Paroxyethira, 392
Paroxypilus, 93
Parydra, 373
Passalidae, 226
Passandrinae, 198
Passion-vine Hopper, 169, Q34
Patagia, 398, 380
Patersonia, insects on, 457
Pauropsalta, 161, *encaustica*, 161; *mneme*, 161; pl.12,f.18
Paussidae, 194
Paussoidea, 194
Paussoptinus laticornis, 215; pl.16,f.14
Pea Weevils, 237
Pear Leaf-curling Midge, 357
Pear-slug, 265, 148
Pecten, cubital, 400
Pectinariophyes, 163; larval tubes, Q23
Pectinate antenna, 15, A4,F
Pectinate type of Venation, 23, A9,B
Pedicel, 14, 287, 339
Pedicinus eurygaster, 135
Pediculidae, 135
Pediculus capitis, 135; *vestimenti*, 135
Pedilidae, 224
Pedilophorus, 206; *gemmatus*, 206; pl.15,f.6; *humeralis*, 206
Pedininae, 222
Pelecorrhynchus, 358; *fulvus*, 359; pl.20,f.20; *nigripennis*, 359; pl.20,f.21
Pelecotomoides, 225; *conicollis*, 225; pl.18,f.18
Pelobiidae, 192
Pelobius, 192
Pelopaeus, see *Sceliphron*
Peloridiidae, 156
Peloridioidea, 156
Peloridium hammoniorum, 156
Pemphigus populi-transversus, 172
Pemphredonidae, 300
Penguin, Little, parasite of, 384
Penis, 27, 38
Penisfilum, 328, 403
Penny Doctors, 192
Pentachrysis imperiosa, 286, T38
Pentacladocera schwarzi, 251; head, 249
Pentacladus, 130
Pentagonica, 192
Pentagonicinae, 192
Pentalonia nigronervosa, 172
Pentaminus, 246
Pentarthrum, 246
Pentatomidae, 148
Pentatominae, 148
Pentatomoidea, 145
Penthea, 234; *saundersi*, 234; pl.19, f.10
Pentozocera, 251; *australiensis*, 251; male, S1; head, S2; larva, S3
Penunci, 141, 388
Pepper-tree, see *Schinus mollis*, 454
Percnodaimon, see *Erebia*, 463
Peremptor, 376
Perga, 265; *cameroni*, 265; *castanea*, 265; *dorsalis* 265, T1; pl.20,f.1; alitrunk, T4; eggs, T10; larva, T11; *lewisi*, 265
Periaptodes, 234
Pericardial cells, 32
Periclystus, 323; *aureolatus*, 323; pl. 11,f.21; *circuiter*, 323; pl.24,f.6; *laceratus*, 323
Pericoma funebris, 350; wing, W20; *townsvillensis*, 350
Pericoptus, 230; *punctatus*, 230; larva, R11
Pericrypta, 56
Perilampidae, 274
Perilampoides bicolor, 274
Perilampus, 274
Perilestes, 78
Periletus leptopsi, 270
Perilissus lutcolator, 265
Periphyra sanguinepunctata, 441; pl. 32,f.11
Periplaneta americana, 92; *australasiae*, 92
Periplanetinae, 91
Peripsocinae, 130
Peripsocopsis, 130
Perissectis australasiae, 413; larval chaetotaxy, 405
Peritheates, 355
Peritreme, 33
Peritrophic membrane, 31
Perkins, R. C. L., 367
Perkinsiella, 152; *saccharicida*, 166, Q31; parasites of, 250, 278, 280
Perlamantinae, 93
Perlaria, 4, 113
Permian Fossil Beds, 469
Permithone, 476; *belmontensis*, 312, 472, ZA5
Permochorista, 472; *sinuata*, ZA3
Permofulgor, 186, 482n; elytron, R16
Permohymen, 256, 257; *schucherti*, T8,B
Permophilidae, 186, 187
Permophilus, 472; *pincombei*, elytron, R17
Permosyne, 186, 472
Permosynidae, 186
Perrisia pyri, 357
Persectania ewingi, 442; pl.32,f.14; head and thorax, Z3; *steropastis*, 442
Pests of stored insects, 496
Petalanthes, 424
Petaliinae, 83

Petalura, 83; *gigantea*, 83; larva, F20,A; *ingentissima*, 83; *pulcherrima*, 83; pl.4,f.1
Petaluridae, 83
Petiolata, 265
Petiole, 259, 287, 339
Pezomachus philpotti, 269
Phacellura indica 432
Phaeodrophilus o'connori, 242; pl.2, f.17
Phaeophanus, 242
Phagocytes, 33
Phagonophana, 208; *alacer*, 208, R39; *kingi*, 208; *latipennis*, 208; *acrosticta*, 208
Phalacridae, 203
Phalacrognathus muelleri, 227; pl.15, f.19
Phalaenoides glycine, 441; enemy of, 148
Phalangitis, 421
Phalidura, 242; *grandis*, 242; pl.19, f.16
Phalidurinae, 242; mimics of, 234
Phaloniidae, 428
Phaneropterinae, 95
Phania verecunda, 376; pl 2,f.30
Phanuromyia, 283
Pharochilus, 226; *dilatatus*, 226; *politus*, 226
Pharyngeal pump, 141
Pharynx, 30
Phasgonura, 95n
Phasgonuridae, 95n
Phasinae, 376
Phasmatidae, 93
Phasmatoidea, 93
Phasmodes ranatriformis, 95
Phaulacridium, 98; *marginale*, 98
Pheidole, 289; *ampla*, 289; *tasmaniensis*, 289; *variabilis*, 289
Pheidolephila, 207
Phellus, 363; *glaucus*, 363; pl.25,f.16
Pheloneis, 222; *multistriatus*, 222
Pheropsophus verticalis, 192; pl.17, f.100
Phibalomyia, 359
Philaenus trimaculatus, 162; pl.2,f.19
Philagra, 162, Q22
Philanisus plebejus, 394, Y13; larva, Y8; case, Y9
Philanthidae, 299
Philenora, 444
Philobota, 424; *arabella*, 424; pl.28, f.26; *sophia*, 424; pl.28,f.25
Philobotinae, 424
Philomastix, 265; *macleayi*, 265; pl. 21,f.2
Philopotamidae, 391
Philopteridae, 134
Philopterus, 134
Philorheithrus, 392; *agilis*, 392; pl. 26,f.10
Philoscaphus, 191
Philotarsus, 130
Philotrypesis, 275
Philpott, A., 172, 402n, 412
Phlebotominae, 350
Phlebotomus queenslandi, 350
Phlepsius, 163
Phloeothripidae, 139
Phloeothrips, 139; *tepperi*, 139
Phlogistus, 213
Phoenicops, 456
Phoracantha, 233; *recurva*, 233; *semipunctata*, 233; *synonyma*, 233, R63; *tricuspis*, 233
Phoridae, 366
Phormium tenax, insects on, 174, 442, 452
Phorocera, 376
Phragma, 11
Phreatoicus, 477
Phryganeidae, 393
Phryganeoidea, 393
Phrynixus, 242
Phthersigena conspersa, 93, G4
Phthirus pubis, 135
Phthorimaea operculella, 426
Phycita, 434; *imparella*, 434; pl.30,f. 15
Phycitidae, 434
Phycochus graniceps, 229
Phycodromia, 371
Phycodromiidae, 371
Phycomorpha, 424
Phycus, 362
Phylacteophaga eucalypti, 265
Phyllocephalinae, 148
Phyllocnistis, 421
Phyllotocus, 229; *macleayi*, 229; *ruficollis*, 229
Phyllotreta regulosa, 236
Phylloxera vastatrix, 172
Phymatophaea, 213
Phymatopsis, 349
Phyracaces, 288
Physapoda, 137n
Physopelta, 147; *guttata*, 147; pl.12, f.3
Physcus, 278
Phytomyza, 372; *affinis*, 372; *albiceps*, 372
Phytophaga, 231
Pie-dish Beetles, 222
Pielus, 413
Pieridae, 463
Piesarthrus, 233; *frenchi*, 233; pl.19, f.8
Piestoceros, 419n
Pigment Cells, 35
Pilifers, 386, 397, 455
Pilinasica cingulata, 368; pl.25,f.23
Pill Beetles, 206
Pill-boxes, 486
Pimplinae, 269
Pinaculum, 406
Pinara, 437; *obliqua*, 437; pl.27,f.24
Pincombea mirabilis, 471, ZA1
Pineus strobi, 172
Pink Boll-worm, 426
Pins, entomological, 490
Pintail Beetles, 225

Pinus radiata, insects on, 172, 232, 242; sugaring, 490
Piophila casei, 372
Piophilidae, 372
Pipunculidae, 367
Pipunculus, 367; *cruciator*, W62
Pirates, 151; *ephippiger*, 151; pl.12, f.15
Piratinae, 151
Pison, 300; *ruficornis*, 300; *spinolae*, 300; pl.21,f.27; *tuberculatus*, 300
Pisonoides, 300
Pittosporum, insects on, 173, 450
Placostylus, 479
Planipennia, 6, 316
Planta, 406
Plant-bugs, 152
Plant-hoppers, 165
Plant-lice, 171
Plantula, 67
Plasma, blood, 33
Plasmodium, 351
Plastogryon, 283
Platanurida, 56
Plataspinae, 149
Platisus integricollis, 199
Platybrachys, 168; parasite of, S6; *decisa*, 168; pl.11,f.16
Platycerus unicolor, parasite of, 384
Platydema, 222
Platyedra gossypiella, 426
Platygasteridae, 283
Platygastoides, 284
Platygerrhus, 276
Platyomida, 242
Platypeza, 366; wing, W58
Platypezidae, 366
Platyphanes, 223
Platypodidae, 239
Platyptilia, 429; *emissalis*, 429
Platypus, 239; *apicalis*, 239, R71; *omnivorus*, 239
Platystominae, 371
Platythyrea, 288
Platyura, 354
Platyzosteria, 91; *novae-seelandiae*, 91
Plautia, 149
Plea, 157
Plecia, 356; *dimidiata*, 356
Plecoptera, see Perlaria
Plectoptera, 57, 3
Plectophila thrasycosma, 426; pl.28, f.37
Plectotarsus, 393, 386; *gravenhorsti*, 394; pl.26,f.14
Pleistodontes froggatti, 276; *imperialis*, 276
Plethogenesia papuana, 63
Pleura, 18, 19
Pleural region, 26; wing process, 21
Pleurites, 10
Pleurota, 425
Pleurotropus epigonus, 278
Plodia interpunctella, 434
Ploearia, 151; *geniculata*, 151; *huttoni*, 151
Ploeariinae, 151
Ploeariodes, 151; *rubromaculatus*, 151
Ploebius, 240; *gigas*, 240
Plotheia, 442
Plume Moths, 428
Plusia, 442; *argentifera*, 443; pl.32, f.18; *chalcites*, 442; pl.32,f.17; larva, Z11; pupa, Z16; *oxygramma*, 443
Plusiinae, 442
Plusiomyia, 349; *gracilis*, 348
Plutella, 421; *cruciferarum*, 421; *maculipennis*, 421
Plutellidae, 421
Poa, insects on, 427; *caespitosa*, 463
Pochadius pilistriatus, 202
Pocket-lens, 498
Podacanthus, 94; *typhon* 94; pl.6,f.4; *wilkinsoni*, 94
Podagriinae, 274
Podagrion, 274
Podagrionella, 274
Podocarpus dacrydioides, insects on, 232
Podomyrma, 288; *gratiosa*, 288, T41
Podopteryx roseonotata, 78; pl.3,f.4
Poduridae, 55
Poecilohetaerus, 371
Poecilometis, 148; *gravis*, 148; pl.12, f.11; *histricus*, 148; *strigatus*, 148
Pogonothynnus, 294
Poliaspis, 174
Policeman Flies, 297, 299
Polistes, 296, 297; *humilis*, 297, T47; *tasmaniensis*, 297; *tepidus*, 296; pl. 21,f.15; *variabilis*, 297
Pollanisus, 435; *viridipulverulentus*, 435; pl.30,f.16
Pollen-plate, 301
Polycentropodidae, 391
Polycestinae, 218
Polychaetophyes, 163
Polychrosis botrana, 427
Polydiapria, 282
Polygrammodes lucalis, 432; pl.30,f.7
Polylobus, 209
Polynema, 279
Polynephric Orders, 32
Polyphaga, 195
Polyplax bidentatus, 135
Polyplectropus puerilis, 391; pl.26, f.5
Polyporus Pith, use of, 490
Polyrhachis, 290; *ammon*, 290, T42; wings, T43; *femorata*, 290
Polystoechetidae, 311, 319
Polythoridae, 79
Polytochus spinicoxa, 371
Polytrophic ovary, 38
Polyzosteria, 91; *mitchelli*, 91; pl.6, f.1
Pompilidae, 292
Ponera, 288; *antipodum*, 288
Ponerinae, 287
Pontolytomyia, 281
Porcorhinus, 165
Porela, 437; *arida*, wings, Z38; *vetusta*, 437; pl.32,f.6; *vitulina*, 437

Porina, 413; *characterifera*, 413; pl. 31,f.1; *fuscomaculata*, 413; *rufescens*, 413; *signata*, 413; *umbraculata*, 413; pl.31,f.2
Porisminae, 320
Porismus strigatus, 320; pl.11,f.20
Porororixa, 158; *eurynome*, 158; *parvipunctata*, 158
Poropterus, 245
Porotermes, 105
Porthesia, 440; *lutea*, 440; pl.27,f.26; *obsoleta*, 440
Post-antennal organ, 53
Postclypeus, 12
Posterior Median, 58, 67, 69, 89
Postnotum, 18
Post-petiole, 287
Postscutellum, 18
Post-sternellum, 19
Potassium cyanide, use of, 487, 488
Potato Moth, 426
Powder-post Beetle, 203
Prasos, 451
Prays, 422
Precis, 463; *orithyra albicincta*, 463; *villida*, 463; pl.43,f.13
Precostal area, 158
Pre-episternum, 19
Prenolepsis, 290; *longicornis*, 290
Prepectus, 19, 254
Prepupa, 261
Prescutum, 18
Preservation of insects, 484
Presternum, 19
Prestwichia, 270n
Prickly Pear, insects on, 174, 272; needles for setting, 490
Principal vein, 158, 171
Prioninae, 232
Prionoplus reticularis, 232; pl.19,f.6; larva, R62; pupa, R14
Pristaulacus, 268
Pristhesancus, 150; *papuensis*, 150; pl.12,f.14
Probetyla subaptera, 282
Problepsis sancta, 452; pl.33,f.25
Prabolus, 269
Proboscis, 336
Processionary Moth, 447
Prochilinae, 95
Procissio, 376
Procladius, 352
Procordulia, 85; *grayi*, 85; pl.2,f.4; *smithii*, 85
Procris, 435
Proctiger, 27
Proctodaeum, 32
Proctotrupes, see *Proctotrypes*
Proctotrypes, 282, 280n; *maculipennis*, 282, T33
Proctotrypidae, 282
Proctotrypoidea, 280
Procympiulus nasutus, 150
Prodenia litura, 441
Prohemerobiidae, 312, 476
Projapygidae, 50
Prolabia arachidis, 112
Prolegs, 406, 405
Prominent Moths, 447
Pronymph, 41, 72
Prophanes, 223; *mastersi*, 223; pl.15, f.7
Propodeum, 253, 254, 259
Propsocus, 130
Propygidium, 182
Proscoporhinus, 240
Proselena, 428
Prosopidae, see Hylaeidae, 302
Prosopis, see *Hylaeus*, 302
Protagriidae, 68
Proteaceae, insects on, 448
Protelater huttoni, 220
Proteodes carnifex, head, Z25
Proterhinidae, 246
Proternia, 431
Proterocosma, 426
Proteroeca, 431
Prothoracic shield, 405
Prothorax, 18
Protialmenus, 465
Protobiella zelandica, 316
Protoblattoidea, 468, 481
Protocerebrum, 13
Protocoleoptera, 186, 187, 472, 481; elytron, R16
Protocoleus mitchelli, 186, 472, ZA6
Protodermaptera, 111, 111n
Protodonata, 67, 68, 468, 481
Protohemiptera, 474n, 469
Protohymen permianus, 256, T8,A
Protohymenoptera, 256, 261, 469
Protolechia, 426; *obeliscota*, pl.28,f.41
Protomecoptera, 330, 475
Protoneuridae, 76
Protopalus schoenherri, 245
Protoplectron, 323
Protorthoptera, 88, 90, 468, 476, 477, 481
Protosynema eratopis, 421
Prototheoridae, 412, 414
Protozygoptera, 73
Protura, 52, 3
Prypnus, 241; *scutellaris*, 241; head, R69
Psammochares, 293
Psammocharidae, 292; mimics of, 363
Pselaphidae, 210
Pselaphinae, 210
Pselaphus, 210; *lineatus*, 210
Psepholax, 245
Psepholus chrysapterygius, 425
Pseudachorutes, 55
Pseudaegeria, 423; *polilata*, 423
Pseudagenia, 293, 292; *fasciata*, 293, T44
Pseudagriinae, 77
Pseudagrion, 77, 70; *aureofrons*, 77; *australasiae*, 77; venation, F7; *ignifer*, 77; pl.3,f.1
Pseudalmenus chlorinda, 465
Pseudatrichia, 362
Pseudoceraphron, 283

Pseudococcus, 174, 205; parasites of, 277; *adonidum*, 174; *calceolariae*, 174; *comstocki*, 174; *maritimus*, 174
Pseudocone, 35, A15
Pseudocubitus, 318
Pseudocconesus, 394
Pseudofoenus, 268; *pedunculatus*, 268
Pseudoformicaleo, 323
Pseudogonatopus, 285
Pseudohydrobius, 197
Pseudolycus, 212, 225; *haematopterus*, 212; *haemorrhoidalis*, 212; *wallacei*, 213
Pseudomedia, 318
Pseudomopinae, 91
Pseudomorphinae, 192
Pseudomyrminae, 288
Pseudoneuria, 436
Pseudopangonia, 359
Pseudoryctes, 230; *monstrosus*, 230; *trifidus*, 230; pl.18,f.32
Pseudosirex, 261
Pseudotabanus, 359
Pseudotaenia, 218; *ajax*, 218
Pseudotrachea, 336
Psilidae, 372
Psilocephala, 362
Psilochorema, 391; *confusum*, 391; *mimicum*, 391
Psilogaster, 275
Psilogramma menephron casuarinae, 448; pl.37,f.2
Psilomella, 281
Psilopus, 365; *fuscatus*, 365, W57
Psocidae, 130
Psocids, 126
Psocoptera, see Copeognatha
Psocus, 130; head, N1,A,B; *lignicola*, venation, N1,C
Psoquillidae, 129
Psorochroa granulata, 220; pl.18,f.23
Psychidae, 435
Psychobiella, 318; *sordida*, pl.22,f.13
Psychoda conspicillata, 350
Psychodidae, 350
Psychodinae, 350
Psychoidea, 434
Psychomyiidae, 392
Psychopsella gallardi, 315
Psychopsidae, 315; fossil, 476
Psychopsis, 315; *coelivagus*, 315; *elegans*, 315; pl.11,f.19; life-history, A21; *insolens*, 315; *mimica*, 315; pl.23,f.1
Psylla, 171; *acaciae-baileyanae*, 171; *sterculiae*, 171
Psyllidae, 170
Psylloidea, 170
Ptenidium, 211; *lawsoni*, 211, R42
Pterodontia mellei, 360
Pterohelaeus, 222
Pterolocera amplicornis, 439
Pteromalidae, 276
Pteromalinae, 276
Pteromalus, 276
Pterophoridae, 428
Pterophoroidea, 428
Pteropleuron, 336
Pterostenus, 234
Pterostichinae, 191
Pterostichus, 191; *meritus*, 191; *opulentus*, 191; pl.17,f.5
Pterostigma, 71, 258
Pterothorax, 18, 67, 177
Pterygogramma, 279
Pterygophorus, 265; *cinctus*, 265; pl.21,f.1; *interruptus*, 265
Pterygota, 3
Ptiliidae, 211
Ptilinum, 334
Ptilocnemus, 151; *femoratus*, 151; pl.6,f.13
Ptilogyna, 348
Ptilomacra, 416; *senex*, 416
Ptinidae, 215
Ptininae, 215
Ptinus, 215; *eminens*, 215; *exulans*, 215, R46
Ptochostola, 433, 430n
Ptomaphila lachrymosa, 208; pl.17,f.24
Pug-moths, 450
Pulex irritans, 384; head, X2
Pulicidae, 384
Pulvillus, 19, 336
Pulvinaria, 174
Pumpkin Beetle, 236
Punctate stria, 473
Pupa, 44
Puparium, 44, 250, 343
Pupipara, 377, 365
Purpuricenus angasi, 234; pl.15,f.26
Puss Moths, 447
Pycnocentria, 394; *evecta*, 394; pl.26,f.15; wings, Y12; *funerea*, 394; pl.26,f.16
Pycnomerus, 200
Pycnosoma rufifacies, 375
Pyge, 111
Pygidicrana, 111
Pygidicranidae, 111
Pygidium, 109, 182
Pygiopsylla, 384; *hoplia*, 384, X1
Pygophor, 141
Pygophora, 374
Pyralidae, 432
Pyralis farinalis, 433; *manihotalis* 433
Pyralites, 431, 429
Pyraloidea, 429
Pyrameis, 463; *cardui kershawi*, 463; *gonerilla*, 463; pl.31,f.33; pupa Z68; *itea*, 463; pl.40,f.12
Pyrausta, 432; *achoealis*, 432; pl.2?,f.22; *albistellaris*, 432; pl.30,f.9; *phoenicialis*, wings, Z32
Pyraustidae, 431
Pyrgomorphinae, 98
Pyrgotis, 428
Pyrochroidae, 223
Pyroderces anaclastis, 426; *terminella*, 426
Pyronata festiva, 229; pl.2,f.13

Pyrrhocoridae, 147
Pythidae, 223

Quadrifinae, 441, 442
Quadrilateral, 69
Quandong, insects on, 424
Quedius, 209
Queen, 102, 287, 305
Queensland Elephant Beetle, 240; Fruit-fly, 372; Leaf Butterfly, 463
Quercus robur, insects on, 278

Racodineura antiqua, 376, 110
Radial cell, 337
Radial sector, 22
Radius, 22
Rallicola, 134
Ramellus, 266
Ranatra, 157; *australiensis*, 157
Rapala, 465
Raphidioidea, 313, 311
Raptoria, 90
Rectum, 32
Red Admiral, 463
Red Bugs, 147
Red Bull-dog Ant, 287
Red Clover, fertilization of, 306
Red-eye Cicada, 162
Red Scale, 174
Reduviidae, 150
Reduviinae, 151
Reduvioidea, 150
Reduviolus, 150
Reduvius personatus, 151
Reepenia, 303
Regent Skipper, 455
Relaxing, 494
Relaxing-box, 486
Reproductive system, 37; internal, A16, A17
Repsimus manicatus, 230
Respiratory system, 32
Retinaculum, 402
Retinula, 35
Returning vein, 180
Rhabdome, 35
Rhaciodes bicaudatus, 243; pl.19,f.21
Rhadinosomus, 241; *lacordairei*, 241; pl.19.f.19
Rhaecocoris sulciventris, 148
Rhagigaster, 294; *unicolor*, 294
Rhagigasterinae, 294
Rhagodolira, 371
Rhamphidia, 348
Rhamphinae, 245
Rhamphomyia, 365
Rhamphophila obscuripennis, 348; wing, W22
Rhamphus, 245
Rhantus pulverulosus, 193
Rhaphidophorinae, 96
Rhapsa, 443; *scotosialis*, 443
Rhicnopeltella eucalypti, 278, T28
Rhinanisus, 246
Rhinaria, 242; *perdix*, 242
Rhinocola corniculata, 171; *eucalypti*, 171; *fuchsiae*, 171, Q36
Rhinocypha tincta, 80; venation, F13
Rhinomacerinae, 244
Rhinorhynchus rufulus, 244, R77
Rhinotia haemoptera, 243
Rhipidocera femoralis, 215; pl.18,f.5; *tesselata*, 215
Rhipidoceridae, 214
Rhipidocerus, 232
Rhipidophoridae, 225
Rhipidothrips cinctus, 138
Rhipipallus, 275
Rhizobius, 205, 174; *ventralis*, 205
Rhizococcus, 174
Rhizopertha dominica, 204, 246
Rhodoneura, 431
Rhogas, 269
Rhopalimorpha, 148; *humeralis*, 148; *ignota*, 148; *obscura*, 148, Q4
Rhopalocera, 454
Rhopalum, 301; *albipes*, 301; *carbonarium*, 301; pl.21,f.29; *tricolor*, 301
Rhotana chrysonoë, 167, Q32
Rhyacophilidae, 391
Rhyacophiloidea, 390
Rhynchiodexia longipes, 376; pl.20, f.29
Rhynchium, 295; *abispoides*, 295; pl. 21,f.13
Rhynchodes ursus, 245
Rhynchophora, 237
Rhynchota, see Hemiptera
Rhyothemis, 86; *graphiptera*, 86; pl.11,f.3; *phyllis chloë*, 86; *resplendens*, 86; pl.11,f.4
Rhyparida didyma, 236
Rhyparosominae, 242
Rhyphidae, 349
Rhyphoidea, 349
Rhyphus, 349; *neozelandicus*, 349; pl. 25,f.3; wing, W25; *notatus*, larva, W13; male genitalia, W10
Rhysodes, 195; *abbreviatus*, 195; *orbitosus*, 195, R23
Rhysodidae, 195
Rhysodoidea, 195
Rhyssonotus, 227; *nebulosus*, 227
Rhytidoponera, 288
Rhytiphora dallasi, 234; pl.19.f.11; *frenchi*, 234
Ricaniidae, 169
Rice Weevil, 245
Ricinus, insects on, 443
Rigor mortis, 490
Rioxa musae, 372
Riptortus, 148; *annulicornis*, 148
Robber-flies, 362
Robinia, insects on, 463
Rodwayia, 211; *orientalis*, 211; pl.16, f.8
Roeselia lugens, 444; pl.39.f.1
Rolling Downs Series, 477
Romna, 152, Q11; *capsoides*, 152; *scotti*, 152
Ropalidia, 296, 297; *cabeti*, 297; *socialistica*, 297; pl.21,f.16; parasites of, 426
Rosama indistincta, 417

Rose Aphis, 172; Chafers, 231; Scale, 174
Rosenbergia, 234; *megacephala*, 234
Rostrum 237
Rove Beetles, 209
Royal Pair, 102
Ruby-wasps, 286
Rupilia, 236
Rutelinae, 230
Rutilia, 376; *decora*, 376; pl.20,f.28; *formosa*, 376; *inornata*, 376; *vivipara*, 376
Rygmodus modestus, 197; pl.17,f.23; *puncticeps*, 197

Sabatinca, 412; *aurella*, 412; pl.38, f.1; *barbarica*, larva, Z19; *calliarcha*, 412; pl.28,f.2; *calliplaca*, 412; *chrysargyra*, 412; maxilla, Z2,A; *ianthina*, 412; pl.28,f.3; *incongruella*, 412; pl.28,f.1; cocoon, Z20; mandibles, Z17; scale from wing, Z4,A; venation, Z18; *sterops*, 412
Saccus, 403
Saetotricha, 395
Sagalassa, 423
Sagephora phortigella, 421; pl.28,f.10
Sagola, 210
Sagria papuana, 235
Sagriinae, 235
Saissetia, 174; *hemisphaerica*, 174; *oleae*, 174
Salda, 154, Q15
Saldidae, 154
Saldoidea, 154
Salius, 292; *bicolor*, 292; *carbonarius*, 292; *diligens*, 292; *marginatus*, 292; *monachus*, 292; *nitidiventris*, 292; *tuberculatus*, 292; *wakefieldi*, 292; pl.2,f.20
Salivary ducts, 31; glands, 31; pump, 141; reservoirs, 31
Salpingus, 223; *bilunatus*, 223, R53; *unguiculus*, 223
Saltatoria, 90
Saluria, 434
Samana, 450; *acutata*, 450; pl.38,f.14
San José Scale, 174
Sand-bugs, 156
Sand-flies, Australian, 352; New Zealand, 355
Sand-wasps, 292
Sandracottus, 193
Santalum acuminatum, insects on, 424
Sophobius, 228
Saprinus, 207; *australasiae*, 207; *laetus*, 207; *pseudocyaneus*, 207, R36
Sapromyza, 371; *dichromata*, 371
Sapromyzidae, 371
Sapromyzinae, 371
Saragus, 222; *incisus*, 222; pl.18,f.13
Sarcinodes, 449, 446n
Sarcophaga aurifrons, 376; *milleri*, 376; *tryoni*, 376, W71
Sarcophaginae, 375
Sarcopsyllidae, 383
Sargiinae, 360
Sargon, 242
Saropogon, 362
Sarrothripinae, 442
Sarrothripus, 442
Sartellus signatus, 209n
Sassafras, insects on, 460
Saturniidae, 453
Satyrinae, 462
Sauris, 452; *hirudinata*, 452; pl.39,f.27
Saw, 265, 259
Saw-flies, 265
Saw-toothed Grain-beetle, 199
Scabella, 373
Scabellum, 239
Scale, 21, 399, N2, W32,B, Z4
Scale insects, 172, 173
Scape, 14, 238
Scaphidiidae, 208
Scaphidium, 208; *alpicola*, 208, R38
Scaphisoma, 208; *concinnum*, 208
Scaptomyza, 373
Scapula, 398
Scarabaeidae, 228; parasites of, 293, 294
Scarabaeinae, 228
Scarabaeoidea, 226
Scaraphites, 191
Scaritinae, 191
Scatophaga, 371
Scatophagidae, 371
Scatopse, 356; *carbonaria*, 356; *notata*, 356
Scatopsidae, 356
Scavenger-flies, 375
Sceleacantha, 232; *gigas*, 232; pl.19, f.4
Scelio, 283; *australis*, 283; *chortoicetes*, 283; *fulgidus*, 283; *ovi*, 283; *punctaticeps*, T34
Sceliodes, 431
Scelionidae, 283
Sceliphron, 300, 301; *laetum*, 301; pl.20,f.12; alitrunk, T6; enemies of, 299; leg, T7,B
Scenopinidae, 362
Scenopinus, 362; wing, W48
Scent-glands, 145, 397
Scent-organs, 412
Schauinslandica, 269
Schiner's Notation, 338
Schinus mollis, insects on, 454
Schizoneura lanigera, 172; *ulmi*, 172
Schizophora, 365
Schizotachina fergusoni, 376; antenna, W1,G
Schoenobiidae, 433
Schoenobius, 433; *imparellus*, 433
Sciadocera rufomaculata, 366, W60
Sciara, 352; *aemula*, wing, W34
Sciarinae, 352
Sciomyza, 371
Sciomyzidae, 371
Scirpophaga, 433
Scitala, 229; *pruinosa*, 229
Sclerite, 10
Scleropepla typhicola, 426

Sclerorrhinus, 242
Scolia frontalis, 295; pl.20,f.9; *soror*, 295; *verticalis*, 294
Scoliacma bicolor, 444; pl.27,f.30
Scoliidae, 294
Scoliinae, 295
Scoliophthalmus, 373
Scolopendrella, 46
Scolopterinae, 244
Scolopterus penicellatus, 245, R78
Scolus, 406
Scolypopa australis, 169, Q34; pl.12, f.26
Scolypopites bryani, 143, 479
Scolytidae, 238
Scoparia, 431; *aspidota*, 431; pl.38, f.6; *exhibitalis*, 431; pl.28,f.56; *feredayi* 432; pl.31,f.11; *hemicycla*, 432; pl.31,f.7; *parmifera*, 432; pl. 31,f.8; *psammitis*, head, Z33; *trapezophora*, 432; pl.31,f.9; *trivirgata*, 432; pl.31,f.10
Scopodes, 192
Scopula, 301
Scorpion-flies, 326; embryo, A19; mouth-parts, A3
Scorpiopsis, 424
Scrobe, 237
Scully, T., 474n
Sculptured Eye, 407
Scutellar margin, 179
Scutellerinae, 149
Scutellista cyanea, 276, T26
Scutellum, 18
Scutiphora pedicellata, 149; pl.12,f.12
Scutum, 18
Scydmaenidae, 208
Scydmaenus, 208
Scymnus, 205; *vagans*, 205
Scythridae, 426
Scythrodes squalidus, 229
Scytinopteridae, 143, 471
Sections, 499
Segmentation, 9
Segments, 10, 11
Selenurus, 212
Selidosema, see *Boarmia*, 450
Selidosematidae, 450
Selys-Longchamps, E. de, 67
Selysian System, 67, 68
Semi-loopers, 405, 442
Seminal vesicles, 38
Semnotes, 348; *ducalis*, 348; *imperatoria*, 348; pl.25,f.1
Senecio, insects on, 440
Sense Organs, 34
Sensilla, 37
Sephena, 169; *cinerea*, 170; pl.6,f.0
Sepsidae, 371
Serial sections, 499
Sericea, 443; *spectans*, 443; pl.36,f.2
Sericoderus, 205
Sericapharus, 299; *reluccns*, 299
Sericostomatidae, 393
Sericostomatoidea, 393
Serphidae, 282
Serphoidea, 280
Serphus, see *Proctotrypes*, 280n
Serrate antenna, 14; A4,C
Serricornia, 195
Sertorius, 165
Sessiliventres, 263
Sessinea, 225; *lineata*, 226
Setting, 492, ZB4; boards, 492; bristles, 493
Sextius, 165; *virescens*, 165, Q27
Shade-midges, 352
Sharp-shooters, 163
Sheep-flies, 375
Sheep-ked, 378
Sheep Nostril Fly, 376
Sheep-ticks, 378
She-oak, see *Casuarina*
Shield-bugs, 148
Shining Wasps, 296
Shore Bugs, 154
Shore Mosquito, 351
Shoulder-tufts, 398
Sialidae, 313
Sialis, 338n
Sialoidea, 313
Side-piece, 339
Sierola, 285, T36; *antipodum*, 285
Sigaus, 98
Sight, Organs of, 34
Signeta, 457
Signiphora, 277
Signiphorinae, 277
Silk-worm Moth, 453
Silky Lacewings, 315; life history, A21
Silky Oak, see *Grevillea robusta*
Silphidae, 208
Silphomorpha albopicta, 192; pl.17, f.12; *grandis*, 192; *speciosa*, 192
Silvaninae, 199
Silvanus surinamensis, 199
Silver-fish, 46, 49
Silver-wire Pins, 490
Silver-Y Moth, 443
Silvestri, F., 52
Silvius, 350
Simaëthis, 423, 4190; *basalis*, 423, pl. 27,f.19; *sycopola*, 423
Simmonds, T. H., 474
Simuliidae, 355
Simulium aurantiacum, 355, W39
Sinella, 56
Siphanta, 169; *acuta*, 169, Q35; pl.6, f.8
Siphlonuridae, 62
Siphonaptera, 380, 7; head X2
Siphunculata, 134
Sira, 56
Sirex juvencus, 263; wings, T9
Siricidae, 263
Sisyra, 317; *brunnea*, 317; wings, U9
Sisyridae, 316
Sisyromyia, 364; *aurata*, 364
Sitarida, 226
Sitodrepa panicea, 215
Sitotroga cerealella, 426
Skeleton, 9
Skippers, 455

Sloane, T., 188
Smell, Organs of, 36
Smicridea, 392; maxilla, Y1,D
Sminthuridae, 56
Sminthurinus, 56
Smoke-fly, 366
Smyrna Fig, cultivation of, 276
Snake-flies, 313
Snellenia, 423; *lineata*, 423
Snow-flake Caddis-flies, 392
Snow-flies, 172
Soap Solution, 499, 500
Social Bees, 305; Wasps, 296
Soft Scales, 174
Solanum, insects on, 236
Soldier Ant, 287; Beetle, 212; Flies, 359
Soldiers, 103, 287
Solenopiella, 282
Solenopsis, 289
Solitary Ants, 295; Wasps, 295
Somatidia, 234; *antarctica*, 234
Somatochlora, 85; *braueri*, 85
Somatopion, 210
Sooth-sayers, 92
Soronia, 202
Sound, Organs of, 36
Sound-producing apparatus (Cicada), Q20
Spalangia nigra, 277
Spaniocerca, 119; *zelandica*, 119; venation, K7
Spaniopsis, 358; *longicornis*, 358; pl. 25,f.5; wing, W45
Spathiinae, 269
Spermatheca, 38
Spermatophore, 38
Spermatozoa, 37
Spermophorella, 315; *disseminata*, 315, U8; *maculatissima*, 316; pl.22, f.4
Sphaerococcus, 174; *pirogallus*, 174; galls, pl.14,f.6
Sphaeroderma rusticum, 157
Sphecidae, 300
Sphecoidea, 297
Sphecodes, 303; *profugus*, 303
Sphecodinae, 303
Sphenarches caffer, 429
Sphenophorus, 246
Sphex, 300, 301; *instabilis*, 301; *suspiciosus*, 301
Sphingidae, 447
Sphinx convolvuli, 447; *godarti*, 448
Sphodrotes, 299
Sphragis, 460
Spicula, 259
Spider-flies, 378
Spider-hunters, 292
Spiders, mimics of, 444
Spiloconis, 320; *maculata*, 320, U14
Spilomicrus nigriventris, 282; *quadriceps*, 282
Spilonota, 427; *contactella*, 427
Spilopyra, 236
Spinneret, 405
Spiracle, 19, 29, 32, A14
Spiral thread, 33
Spittle-insects, 162
Spondyliaspis eucalypti, 171
Spongilla-flies, 316
Spoon-winged Lacewings, 321
Spring, 54, D1,D
Spring-tails, 53
Spurs, tibial, 19, 388
Squame, 66, 336
Squash Bugs, 147
St. Peter's Triassic Beds, 474, 477
Stable-fly, 375
Stag Beetles, 227
Staining, 500
Staphylinidae, 209
Staphylininae, 209
Staphylinoidea, 207
Staphylinus, 209; *huttoni*, 209; pl.17, f.27; labium, R37
Star-psylla, 171
Stathmopoda, 423, 408; *arachnophthora*, 423; *callichrysa*, 423; pl.21, f.20; *crocophanes*, 423; *phlegyra*, 423
Stauralia, 148
Stauropus, 446
Stegomyia fasciata, 351
Stem-mothers, 171
Stenobiella, 316; *hirsutissima*, pl.22, f.5
Stenocotinae, 165
Stenocotis caudata, 165; pl.12,f.23; *planiuscula*, 165
Stenoderus, 234
Stenolaemus, 151
Stenopelmatinae, 97
Stenoperla, 117; *australis*, 117; pl.10, f.6; *prasina*, 117; pl.2,f.5
Stenophasmus, 268
Stenopodinae, 151
Stenopsychodes, 391, 386; *hiemalis*, 391; pl.25,f.7; *melanochrysa*, 391; pl.11,f.22; *montana*, 391; pl.25,f.6
Stenopsocus, 130
Stenoptilia, 429; *celidota*, 429; *zophodactyle*, 429
Stenosialis, 313
Stenosmylus, 320; *latiusculus*, 320; pl.24,f.1; *tasmaniensis*, 320
Stenotarsus, 204; *arithmetirus*, 204; 5-*notatus*, 204, R33
Stenotus binotatus, 153
Stephanidae, 268
Stephanus, 268; *crassicauda*, 268; pl. 21,f.3
Stephanocircus, 384; *dasyuri*, 384, X5
Stephanopsylla, 384
Stephanorhynchus, 243
Sternaulax zelandicus, 207
Sternellum, 19
Sternite, 10, 25, B1,F
Sternolophus nitidulus, 197
Sternopleuron, 336
Sternorrhyncha, 170
Sternoxia, 215
Sternum, 10, 18, 19
Sterrhidae, 451

Stethaspis, 229; *eucalypti*, 229
Stethomela, 236
Stethopachys formosa, 235
Stethynium, 280
Sthenopsis, 412
Stick Insects, 93
Stick-tight Flea, 383, 382
Stictopterinae, 442
Stictotrematoidea, 251
Stigma, see Spiracle, 32
Stigmatomma, 288
Stigmodera, 217; larva, R48,C; *cyanicollis*, 217; pl.15,f.13; *gigas*, 217; *grandis*, 217; *gratiosa*, 217; *heros*, 217; *jacquinoti*, 217; *macfarlanei*, 217; *macularia*, 217, R48,A,B; *nasuta*, 217; *ocelligera*, 217; *pascoei*, 217; *roei*, 217; *saundersi*, 217; *suturalis*, 217; pl.15,f.12; *tibialis*, 217; pl.18,f.26
Stigmoderinae, 217
Stilbopterygidae, 324
Stilbopteryx, 324; *costalis*, 324; *linearis*, 324; *napoleo*, 324; pl.24,f.9
Stilbula, 275
Stilbum cyanurus, 286; *splendidum*, 286; pl.20,f.5
Stilida indecora, 148
Stilt Bugs, 148
Sting, 259
Stink-bugs, 148
Stink-flies, 318
Stipes, 15
Stizidae, 299
Stizus, 299; *turneri*, 299
Stolotermes, 105; *brunneicornis*, 105
Stomach, 31
Stomatoceras, 274
Stomodaeum, 31
Stomoxys calcitrans, 375, 343
Stone-flies, 113
Store-boxes, 495
Storeus, 243
Storing insects, 495
Stratiomyiidae, 359
Stratiomyiinae, 360
Streblidae, 378
Strepsiptera, 6, 249
Stria, 179
Strigil, 399
Striglina, 430, *pyrrhata*, 430, 431; pl.27, f. 17; *scitaria*, venation, Z31
Stropis maculosa, 98
Strumigenys, 289
Study, methods of, 484, 498
Stygia, 416
Stylaclista, 281
Style, 26, 27; anal, 141
Styliform appendage, 127
Styphelia, insects on, 172
Styphlolepis, 433; *hypermegas*, 433
Subcosta, 22
Subcostal cell, 436
Subgenital plate, 27, 59
Subimago, 44, 61
Submentum, 16
Subnodus, 68
Suboesophageal ganglion, 13
Subtriangle, 80
Subulicorn antenna, 14, A4,A
Sugar-ant, 290
Sugar-cane Beetle, Greyback, 230
Sugar-Cane Hopper, 166, Q31
Sugar-lerp Insect, 171
Sugaring, 489
Suhpalacsa, 324; *flavipes*, 324; pl. 24,f.10; larva, U6; *subtrahens*, 324
Sulphur Butterflies, 464
Supella, 91
Supra-anal plate, 27
Supra-oesophageal Ganglion, see Brain
Supra-triangle, 81
Suranal plate, 405
Susica collaris, 436; pl.33,f.14; *semicana*, 436; pl.32,f.4,5; larva, Z36; pupa, Z37
Sutural margin, 179
Suture, 179, 10
Swallow-tails, 458
Sweet Potato, insects on, 440
Swift Moths, 413
Sword-grass, see *Gahnia*, 457
Syagrius, 242
Syarbis, 242
Sycopteron symmetricum, 261
Sycorax, 350
Sycoryctes, 275; *australis*, 275
Sylepta, 432; *clytalis*, 432; pl.30,f.8
Syllitus, 234
Sympetes macleayi, 222
Sympetrinae, 86
Sympherobiinae, 318
Symphita, 263
Symphyletes, 234; *vestigialis*, 243
Symphypleona, 56
Synchorema, 391
Synemon, 417; *catocaloides*, 418; *directa*, 418; *hesperoides*, 417; pl. 30,f.4; *leucospila*, venation, Z23
Syngaster lapida, 269; wings, T19
Synlestes, 78, 70, 71, 79, 477; *weyersi*, 78; pl.3,f.2; labium, F2,D; larva, F11,C; ovipositor, A10; venation, F8
Synlestidae, 78
Syntheminae, 84
Synthemis, 84; *eustalacta*, 84; larva, F21,A; *macrostigma*, 84; *regina*, 84; pl.5,f.3; venation, F16
Synthemiopsis, 84; *gomphomacromioides*, 84; pl.5,f.4
Syntheta smaragdistis, 441
Syntomactis, 426; *macrostola*, 426
Syntomidae, 444
Syntomis, 444; *annulata*, 444; venation, Z42
Syrphaetodes, 222; *tuberculicostatus*, R52
Syrphidae, 368; parasites of, 269
Syrphoidea, 366
Syrphus, 368; *novae-zealandiae*, 368, W61; *viridiceps*, 368
Systasis, 277

Systelloderes, 151; *aetherius*, 151
Systellopus, 229
Systoechus, 364; *crassus*, wing, W55; *platyurus*, 364
Systolomorphella, 274
Systropinae, 364
Systropus clavifemoratus, 364, W50

Tabanidae, 358; pupa, W20
Tabaninae, 359
Tabanoidea, 357
Tabanus, 359; *alternatus*, 359; *circumdatus*, 359, W43; antenna, W1, D; mouth-parts, W3; tarsus, W6; *impar*, 359; *regis-georgii*, 359; *sanguinarius*, 359; *sordidus*, 359; *victoriae*, 359
Tabby Moths, 433
Tachardia australis, 174; *decorella* 174
Tachardiinae, 174
Tachinidae, 375; fissicorn, 376
Tachininae, 376
Tachinophagus australiensis, 277
Tachynomia, 294
Tachyporinae, 209
Tachysphex, 299; *australis*, 299
Tachytes, 299; *approximatus*, 299; *nigerrimus*, 299; pl.21,f.24; *sericops*, 299
Tachyusa, 209
Tactile hairs, 37
Taeniochorista, 331; *pallida*, 331
Taeniogonolos maculatus, 291
Taeniorrhynchus, 351
Talaurinus, 242
Taleporia, 421; *scotinopis*, pl.28,f.9
Talerax, 219
Talis, 433; *bivittella*, 433; pl.30,f.12; *crypsichroa*, 433; *leucophthalma*, 433; *megalarcha*, 433; *pleniferella*, 433; pl.30,f.11; *recurvella*, 433
Tamasa, 161
Tanychilus splendens, 223; pl.18,f.14
Tanyderidae, 347
Tanyderus, 347; *annuliferus*, 347; wing, W31; *forcipatus*, 347; pl.2, f.23
Tanypezidae, 371
Tanypus, 352
Tanyrhininae, 242
Tanyzonus bolitophilae, 282
Tapeigaster, 371
Tapinoma odour, 289
Tarphiomimus wollastoni, 200, R26
Tarsostenus, 213
Tarsus, 19, W6, W7
Tartessus, 163
Tasmania, Insect fauna of, 479
Tasmanica myrmecophila, 246
Tasmanoperla, 118; *diversipes*, 118; pl.10,f.11; *ruficosta*, 118; pl.10,f.12; *thalia*, 118
Tasmanophlebia lacustris, 62; pl.10, f.3
Taste, organs of, 36
[illegible]
Tatosoma, 452; *lestevata*, 452; pl.; f.27; *tipulata*, 452; pl.31,f.30
Taxeotis, 449
Tea-tree, see *Leptospermum* a *Melaleuca*
Techmessa, 225
Technomyrmex, 290
Tectocoris lineola, 149; pl.13,f.13
Tegmen, 87, 141, 158, 182
Tegula, 18, 165, 254, 380, 398
Tegumen, 403
Teinobasinae, 77
Teinobasis, 77
Telenomus, 283
Telephlebia, 84; *godeffroyi*, 84; pl f.3
Telephoridae, 212
Telephorinae, 212
Telephorus, 212; *nobilitatus*, 212
Telicota augias krefftii, 456
Tellerva, 461
Telmatophilus, 202
Tel[illegible] wollastoni, 234; pl.19,f.9
Telofilum, 27
Telotrophic ovary, 38
Telson, 27, 109
Tenaculum, 54
Tenebrio molitor, 223; *obscurus*, 223
Tenebrioides mauritanicus, 201
Tenebrionidae, 221
Tenebrioninae, 222
Tenebrionoidea, 220
Teneral forms, 44
Tenodera australasiae, 93; pl.6,f.5
Tenthredinidae, 265
Tenthredinoidea, 263
Tentorium, 11, 12
Tephritis, 372
Teramocerus barbicornis, 240
Terias, 464; *hecabe sulphurata*, 464; pl.44,f.13; *smilax*, 464
Terebra, 259
Terebrantia, 138
Terentius, 165
Tergite, 10, 25
Tergum, 10, 18
Termen, 25, 399
Termitarium, 100, 102; pl.9,f.1-4
Termites, 100
Termitidae, 106
Tertiary fossils, Australian, 478, 479
Tessaratominae, 148
Tessaratoma, 233; *sericans*, 233; *undatum*, 233
Testis, 38
Testrica, 149; *bubala*, 149
Tetrachrysis, 286; *verreauxi*, 286
Tetraleurodes stypheliae, 172
Tetralobus, 220; *corrosus*, 220; pl.18, f.24
Tetralonia, 304
Tetralophus, 242
Tetraponera, 288
Tetrastichinae, 278
Tetrastichus, 278
Tetratheminae, 85, 86
Tetrathemis, 86

Tetrigus, 220; *australicus*, 220
Tetrorea, 234
Tettigarcta, 161; *crinita*, 161; pl.11, f.11; *tomentosa*, 161
Tettigarctinae, 161
Tettigia, 162
Tettigidae, 99
Tettigometridae, 143, 165, 475
Tettigonia, 95n; *viridissima*, 95n
Tettigoniidae, 95
Thalaina, 451; *clara*, 451; pl.33,f.21
Thallarcha, 444
Thallis compta, 203
Thamnosura, 425
Thanatodictya, 168; *hebe*, 168; *tillyardi*, 168; pl.2,f.11
Tharra, 163
Thaumalea, 352; wing, W29
Thaumaleidae, 352
Thaumasura, 276; *rubrofemoralis*, 276; *terebrator*, 276
Thaumatoperla robusta, 118; pl.10,f.9
Thaumatosoma, 304
Thea opaca, 171
Theca, 335
Thechia, 243
Theclinae, 465
Theoxena, 450
Theretra, 449; *clotho*, 449; *inornata*, 449; *latreilli*, 449; *nessus*, 449; *oldenlandiae*, 449; pl.36,f.8; *queenslandi*, 449; *tryoni*, 449; *turneri*, 449
Thereutria, 363; *amaraca*, 363
Therevidae, 362
Thiotricha, 426
Thopa, 162; *saccata*, 162; *sessiliba*, 162; pl.11,f.12
Thoracic sclerites, Diptera, W12
Thoramus wakefieldi, 220, R51,A
Thorax, 18, 9
Thraulus, 64
Thread-winged Lacewings, 321
Thripidae, 139
Thrips, 136; *tabaci*, 139
Throscidae, 219
Throscus, 215
Thudaca, 424; *obliquella*, pl.28,f.22
Thyada barbicornis, 234
Thylacoscelis, 423
Thynnidae, 293; mimics of, 234
Thynninae, 294
Thynnoides mesopleuralis, 294, T46
Thynnoturneria, 294; *cerceroides*, 294
Thynnus, 294; *pulchralis*, 294
Thyrassia inconcinna, 435
Thyrididae, 430
Thyrsophoridae, 128
Thysanoptera, 136, 5
Thysanura, 46, 3
Thysonotis, 466; *hymetus*, 466; pl.44, f.16,17
Tibia, 19
Tibial Spurs, 388
Tibicininae, 161
Tiger Beetles, 192
Tiger Moths, 444
Tigones, 242; *flectiscapus*, 242
Tillyardia, 232; *mirabilis*, 232; pl.19, f.5; palpi, R64
Timbal, 160
Timberlake, P. H., 279n
Tinea, 421; *dicharacta*, 421; *fuscipunctella*, 421; *margaritis*, 421; *mysticopa*, head, Z24; *pusilla*, 421; *terranea*, venation, Z27; *xystidophora*, 421; pl.28,f.8
Tineidae, 419
Tineinae, 420
Tineodidae, 430
Tineoidea, 418; heads, Z24-Z26
Tineola biselliella, 421
Tingidae, 152
Tingoidea, 152
Tiphobiosis, 391, 393
Tipulidae, 347
Tipulinae, 348
Tipuloidea, 347
Tirathaba parasitica, 434
Tisiphone, 462; hybrids, 462; *abeona*, 462; race *albifascia*, 462; pl.43,f.11; race *morrisi*, 462; pl.43,f.12; race *rawnsleyi*, 462; larva, Z67; venation, Z64; *helena*, 462
Tisobarica, 424; *pyrrhella*, 424; pl.28,f.24
Titanolabis, 111; *colossea*, 111, J1, J2
Titanomis, 420; *sisyrata*, 420; fore tibia, Z3,C; maxilla, Z2,C
Tmesiphorus, 210
Tocris, 242, *latirostris*, 242; pl.19,f.15
Toe-biters, 157
Tomatoes, insects on, 443
Tomicus, 239
Tomocera, 276
Tomocerinae, 56
Tongue, of bees, 253, 301
Tonnoir, A., 343n
Tonza purella, 421
Torma, 335
Tornus, 25
Tortoise Beetle (New Zealand), 207
Tortoise Beetles, 237
Tortoiseshell Butterfly, Australian, 463
Tortricidae, 427
Torticites, 426, 418
Tortricopsis aurata, 424, 425; pl.27, f.14
Tortrix, 427, 428; *desmotana*, 427; pl.28,f.45; *erysibodes*, 427; *excessana*, 428; pl.31,f.3; head, Z26; larva, Z10; pupa, Z15; venation, Z30; *pictoriana*, 428; pl.28,f.47; *postvittana*, 427; *tasmaniana*, 427; pl.28,f.46
Tortyra, 419n
Torymidae, 275
Torymus, see *Callimone*, 275
Touch, organs of, 37
Toxicum, 222
Toxidia, 457
Toxoptera aurantii, 172
Toxura, 371
Trachea, 32

Tracheal studies, methods of, 500
Tracheoles, 33
Tracheomyia macropi, 376
Trachypepla, 424
Trachypetus clavatus, 269; pl.20,f.4
Trachys, 217
Tramea, 80; *loewii*, 86; pl.4,f.8; head of larva, F5,D
Trameinae, 86
Tranes monopticus, 243
Transfer apparatus, 182
Transverse cord, 119, 393
Trapezites, 457; *symmomus*, 457
Trapezitinae, 457
Traps for insects, 489
Travelling Butterfly, 464
Tree-hoppers, 165
Tree Weta, head, A2
Tretothoracidae, 222
Tretothorax, 221; *cleistostoma*, 221; pl.16,f.18
Triacanthella alba, 55
Triad, 23, 58
Triadic type of venation, 23, A9,C
Triangle, 81
Trias of Germany, 469
Triassagrion, 73, 476
Triassic Fossil Beds, 473
Triassocoridae, 143, 475
Triassolestes, 69, 70, 73, 476; *epiophlebioides*, venation, F4,A
Triassolocusta, 476
Triassomantis, 476
Triassopsychops superba, 312, ZA10
Tribocephalinae, 151
Tribolium ferrugineum, 223
Trichalus, 213
Trichananca, 224
Trichaulax, 231; *phillipsi*, 231; pl.18, f.33; *trichopyga*, 231
Trichilogaster, 274
Trichocera annulata, 348
Trichocerinae, 347
Trichocoides, 284
Trichodectes, 134; *bovis*, 134; *climax*, 134; *ovis*, 134; *pilosus*, 134; *subrostratus*, 134
Trichodectidae, 134
Trichogen cells, 37
Trichogramma, 279; *pretiosa*, 279
Trichogrammatidae, 279
Trichomyia, 350
Trichomyiinae, 350
Trichophaga tapetiella, 421
Trichophthalmus, 361; *nigripes*, 361; pl.25,f.13; *novae-hollandiae*, 361; wing, W47
Trichophthicus, 374
Trichopria, 282; *longiclava*, T32
Trichopsidea, 361
Trichoptera, 385, 7; male genitalia, Y2
Trichopterygidae, 211
Trichorrachus, 265
Trichosia, 352
Trichosternus, 191; *antarcticus*, 191; *crassalis*, 191; *imperialis*, 191; *renardi*, 191
Trichrysis, 286
Tricladus froggatti, 130
Triclonus, 363
Tricondyla aptera, 192
Trictena, 413; *labyrinthica*, 413
Trielis, see *Campsomeris*
Trifinae, 441, 442
Trigona, 305, 202; *carbonaria*, 305, T53
Trigonalidae, 291
Trigoniza, 98; *campestris*, 99
Trigonometopus, 371
Trigonotarsus rugosus, 245, R82
Trilobites, 214
Trimera, 128
Trinotoperla australis, 119; pl.10,f.15; *irrorata*, 119; pl.10,f.14
Trioza, 171; *carnosa*, 171; *casuarinae*, 171; *eucalypti*, 171
Triphyllus, 202; *intricatus*, 203
Triplectides, 392; *amabilis*, 392; pl.26,f.11; *obsoleta*, 392
Triscolia, see *Scolia*
Tritocerebrum, 13
Triungulin, 183, 226, 250
Trixagidae, 219
Trochanter, 19
Trochantin, 18
Trochilium chrysophanes, 424, Z29; *tipuliforme*, 424
Troctes divinatorius, 129, 496
Troctidae, 129
Trogidae, 227
Trogocerus formosus, 233; *lepidopterus*, 233
Trogodendron fasciculatum, 213; pl.18,f.7
Trogoderma, 206; *morio*, R35
Trogositidae, 200
Troides, 458; *priamus*, 458; *euphorion*, pl.40,f.4; *richmondius*, 459
Tropidoderus, 94; *rhodomus*, 94
Tropiduchidae, 166
Trox elderi, 228; *gigas*, 228
Trybliographa, 271
Trygodes, 451
Trymalitis, 427; *optima*, 427; pl.33, f.7
Trypaneidae, 372
Trypeta, 372
Trypetidae, 372
Tryphon, 269
Tryphoninae, 269
Trypoxylidae, 300
Trypoxylon, 300; *connexum*, 300, T49
Tryxalinae, 98
Tsetse-flies, 342, 365n
Tubulifera, 139
Turner, A. J., 414, 415n, 425
Turneria, 290
Tussock Grass, insects on, 463
Tussock Moths, 440
Two-winged Flies, 333
Tychinae, 245
Tylozygus, 163; *cossiniae*, 163, Q24
Tympanum, 160
Tyora sterculiae, 171
Typhaea, 202; *hirta*, 202, R29
Typhlocyba, 163; *australis*, 163, Q26

Typhlocybinae, 163
Tyromorphus, 210

Ubida, 433; *ramostriella*, 433; pl.33,f.13
Ufens, 279
Ulodes, 222
Ulodinae, 222
Uloma westwoodi, 222
Ulominae, 222
Ulonotus, 200
Uncinia, insects on, 462
Uncus, 403
Unio, 477
Unionella, 477
Upper Carboniferous Period, 469
Upper Permian Fossil Beds, 469
Upper Triassic Fossil Beds, 469
Uracanthus, 233; *crytophagus*, 233; *triangularis*, 233; pl.19,f.7
Uraniidae, 445
Uranioidea, 444
Urellia, 372
Urolabinae, 148
Uromycladium, 202
Urophora, 372
Uropetala, 83; *carovei*, 83
Uropsylla, 384
Urtica, insects on, 463
Urticating hairs, 439, 440
Utethesia pulchella, 444
Uzucha, 425; *humeralis*, 425; pl.30, f.2

Vagina, 38
Valves, 403
Varnia, 314
Vasa deferentia, 38
Vedalia cardinalis, 205
Vegetable caterpillars, 413
Vegetable Creek Fossil Beds, 479
Veinlets, 24
Veins, 24
Veliinae, 153
Vena dividens, 25, 88, 141, 158
Vena spuria, 366, 368
Venation, hypothetical type, A8
Ventral diaphragm, 34
Ventral plate, 59
Ventral tube, 53
Venusia, 452; *prefectata*, 452; pl.33, f.26; *verriculata*, 452; pl.31,f.29; *xanthaspis*, 452; pl.38,f.25
Verandah Beetles, 222
Vermiform larvae, 42, 183
Veronatus, 214; *longipalpis*, 214; R45
Veronica, insects on, 372
Verrall, G. W., 338n
Verruca, 406, 453
Vertex, 12
Vespidae, 296
Vespoidea, 290
Vibrissa, oral, 341
Vinculum, 403
Vine Moth, 441, 148
Vine-Scourge, 172
Vipio, 269
Vipioninae, 269
Vitelline membrane, 39
Vitessa, 433; *glaucoptera*, 433
Vitis, insects on, 448
Voliba, 431, 429n
Vulturnus, 163

Wallaby Louse-fly, 377
Wanderer Butterfly, 461
Waratah, see *Telopeia*, 436
Wasp, English, 296
Wasp-flies, 370
Wasps, 290, 292; mimics of, 234, 362
Wasps' Nests, insects in, 435
Water Beetles, 192
Water-boatmen, 158
Water-rat, Native, parasite of, 384
Water-scorpions, 157
Water-striders, 153
Waterhouse, G. A., 462
Watt, M., 372, 421
Watt'e, see *Acacia*
Wattle Pig Beetle, 242
Wave Moths, 451
Wax Moths, 434
Web-spinners, 120
Weeleus, see *Myrmeleon*, 324
Weevil, Biscuit, 215
Weevils, 237, 176, 241
Westwoodiella, 269
Weta, 89, 95, 97
Wheat, insects on, 357, 425, 442
Whirligig Beetles, 193
Whistling Moth, 441
White Ants, 100
White-banded Cicada, 162
White Cedar, see *Melia*, 441
White-flies, 172
Whites, 463
Wianamatta Shale Beds, 477
Wild Caper, see *Capparis*, 464
Wild Cotton-plant, 462
Wilkiea macrophylla, insects on, 456
Williston, S. W., 338n
Wineberry, see *Aristotelia*, 413
Wing, 20
Wing-cases, 20
Wing-coupling apparatus, 402, Z6, 309, 386
Wing-margin, 25
Wing-sheath, 20
Wing-spot, 387
Wing-veins, 20
Wing-venation, 21; hypothetical type, A8
Wingia, 424; *hesperidella*, 424; *lambertella*, 424; pl.27,f.13; venation, Z28
Wireworms, 220
Wongera-wongera, 78
Wood Moths, 416
Woolly Aphis, 172; parasite of, 278
Woolly Bear, 444
Workers, Isoptera, 102; Ants, 287; Bees, 305

Xanthagrion, 77; *erythroneurum*, 77
Xanthocnemis, 77; *zelandica*, 77; pl. 2,f.3
Xantholeon helmsi, 324; pl.22,f.3
Xantholinus, 209

Xanthorhoe, 452; *adonis*, 452; pl.38, f.24; *cataphracta*, 452; pl.38,f.21; *heliacaria*, 452; pl.39,f.21; *helias*, 452; pl.38,f.22
Xanthorrhoea, insects on, 207, 234, 245, 305, 368, 434
Xenica, 462, 455; *acantha*, 462; pl. 43,f.6; *klugi*, 462
Xenocerus leucogrammus, 240; pl.19, f.13
Xenoidea, 251
Xenolimnophila, 349
Xenolispa, 374
Xenophyes cascus, 156, Q16
Xenopsylla cheopis, 384
Xerotes, insects on, 457
Xestocephalus, 163
Xiphidiinae, 95
Xiphidium semivittatum, 95
Xiphydria, 264; *decepta*, 265, T14; *obtusiventris*, 265
Xiphydriidae, 264
Xyelidae, 257
Xyleborus, 239
Xyleutes, 417; *boisduvali*, 417, 408; *donovani*, 417; pl.35,f.1; *eucalypti*, wings, Z22
Xylion collaris, 204; *cylindricum*, 204
Xylobosca bispinosa, 204
Xylochus, 223
Xylocopa bryorum, 304; pl.20,f.16; parasite of, 304
Xylocopidae, 304
Xylol, use of, 497
Xylonichus, 229
Xyloperga, 265
Xylophilus, 224
Xyloryctа, 425; *porphyrinella*, 425; pl.27,f.16; *strigata*, 425
Xyloryctidae, 425
Xyloteles, 234
Xylotrupes australicus, 230; pl.18,f.31
Xyrosaris, 422
Xyroscelis, 218

Yarumpa, 290
Yellow fever, carrier of, 351
Yellow Monday Cicada, 162
Yellows, 463
Yolk, 39
Ypthima arctous, 462

Zagrammasomoides fasciatus, 228
Zaluscodes aucklandicus, 348
Zanessa, 152; *rubrovariegata*, 152
Zaprochilus australis, 95
Zaspilothynnus, 294; *carbonarius*, 294; *excavatus*, 294; *variabilis*, 294; pl. 20,f.7; *vernalis*, 294
Zelandobius, 119
Zelandoperla, 119; *decorata*, 119; pl. 10,f.17
Zelandopsocus formosellus, 130; pl.2, f.7
Zelandopsyche, 394; *ingens*, 394; pl. 26,f.13; head, Y1,C
Zelandoptila, 393; *moselyi*, 393
Zelleria, 422, 419n
Zenarge, 265
Zeuzera, 417
Zeuzerinae, 417
Zia tactalis, 444
Zinc Relaxing Box, 486
Zinckenia, see *Hymenia*, 432
Zizina labradus, 466; *oxleyi*, 466
Zoedia, 234
Zonioploca, 91
Zonitis, 226; *purpureipennis*, 226; *tricolor*, 226; pl.18,f.21
Zonopetala, 425; *divisella*, pl.28,f.29
Zopherosis, 221; *georgei*, 221; pl.18, f.11
Zophosinae, 221
Zorion minutum, 233; pl.2,f.16
Zoraida, 167
Zoraptera, 124, 4
Zorotypidae, 125
Zorotypus, 125; *guineensis*, M1; *hubbardi*, venation, M2
Zoyphium, 299
Zygaenidae, 435
Zygaeninae, 435
Zygaenoidea, 434
Zygomyia, 354
Zygoneura, 352
Zygopinae, 245
Zygoptera, 74

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